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**A STUDY OF THE DISTRIBUTION AND ECOLOGY OF THE
SAXICOLOUS MOSSES GRIMMIA ANODON, G.
PLAGIOPODIA AND G. PULVINATA IN SOUTHERN
ONTARIO**

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The genus *Grimmia* in eastern North America comprises some 28 taxa of saxicolous mosses and is recognized as an inclusive genus by Crum and Anderson (1981). Other authors have divided the genus to include *Grimmia*, *Coscinodon*, *Schistidium* and *Jaffueliobryum*. Although no taxonomic preference is recognized by this author, it has been convenient to follow the division of the genus for the purpose of this study.

The three species studied here are calciphilic mosses with centers of distribution in the mountains of the west, where their habitat preference is described as dry, exposed sandstone or calcareous rock. Until recently, their occurrence in eastern North America was known from only a few widespread locations from the Dakotas eastward to the Atlantic seaboard (Ireland & Miller 1982). In Ontario, this specialized type of habitat is supplied by natural rock outcroppings, old weathered concrete and the cut limestone blocks used in man-made structures such as bridge abutments and tombstones (Fig. 1). In the agricultural areas of southwestern Ontario, where few rock outcroppings occur, the required type of calcareous habitat is most frequently encountered in cemeteries, where these mosses have been found growing on old concrete walls and the calcareous bases of tombstones. In fact, cemeteries provide a somewhat evenly distributed source of suitable habitat for these mosses in southern Ontario even in areas where the appropriate substrate is not otherwise found.

Grimmia anodon B.S.G. is a circumboreal species, reported from Britain, Europe, the Caucasus, west and central Asia, Tibet, Algeria, Morocco, Greenland and North America. The North American distribution is reported as Ellesmere Island, Alaska, Yukon to California, Arizona, New Mexico, Northern Mexico, North and South Dakota, Illinois, New Brunswick and Ontario. It has also been reported from Oregon. Smith (1978) reports it as very rare in Britain (sites in 3 vice-counties) and in North America its distribution is given by Crum and Anderson (1981) as very rare in the east. In Ontario, it was first collected at Port Arthur (Thunder Bay) on April 10, 1968 (C. E. Garton, 10574) and subsequently in Elgin County on July 2, 1972 (Stewart 1197, MICH). Both collections were on tombstones. It has since been collected on very old concrete and the calcareous bases of tombstones.

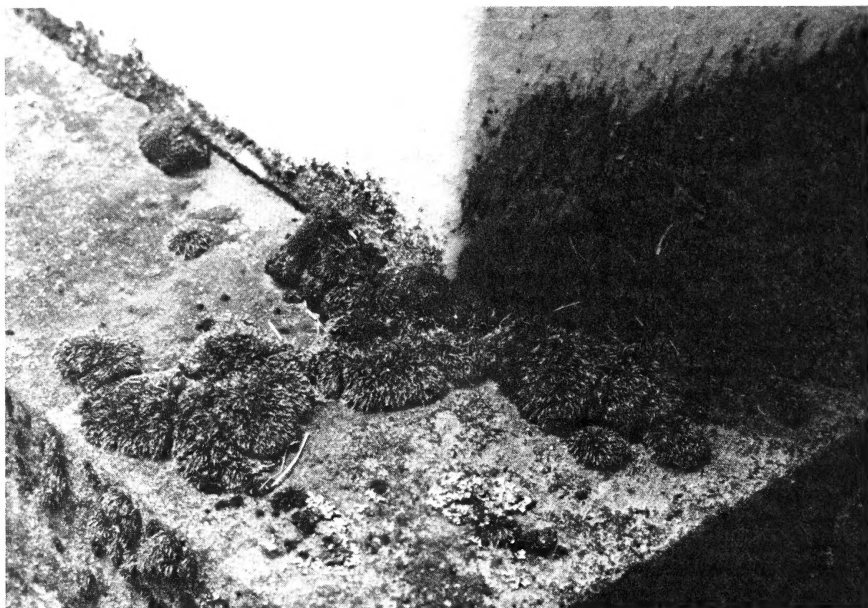


Fig. 1. A typical colony of *Grimmia plagiopodia* Hedw. growing on the limestone base of a tombstone in southern Ontario.

Grimmia plagiopodia Hedw. is also a circumboreal species, reported from central Europe, the Caucasus, central Asia and Greenland. It is not reported from Britain by Smith (1978). In North America it has been reported from arctic Alaska, British Columbia to Ontario, Ohio, Maryland, California, New Mexico, Nebraska, Iowa, Wisconsin, Michigan, Nevada and Oregon. Crum and Anderson (1981) report it as rare and scattered in the east, more common in the west. In Ontario, *G. plagiopodia* was first collected in Elgin County on July 11, 1969 (Stewart 602, MICH) on calcareous stone blocks of an old railway bridge abutment. It has since been collected on calcareous cemetery substrates and old concrete.

Grimmia pulvinata (Hedw.) Sm. is a cosmopolitan species reported from all of the vice-counties of Britain and Ireland and the Channel Islands. It is reported from the Faeroe Islands, central Europe, Caucasus, west and central Asia, Macaronesia, Tunisia, Morocco, Algeria, Ethiopia, North America, Greenland, Australia, New Zealand, Himalayas, Japan, Hawaii and Africa. The North American distribution is given as Illinois, Indiana, Iowa, Kansas, Michigan, Missouri, Ontario, Maryland, Oklahoma, British Columbia to California and inland to Utah, Colorado, Texas and northern Mexico. It is reported as common in Britain by Smith (1978) and as rare and scattered in eastern North America by Crum and Anderson (1981). *Grim-*

TABLE 1. Alphabetical list of the Counties and Districts of Southern Ontario represented in the collections.

<i>Grimmia anodon</i> B.S.G.		
Brant Co.	Lambton Co.	Peterborough Co.
Bruce Co.	Lennox & Addington Co.	Renfrew Co.
Dufferin Co.	Middlesex Co.	Simcoe Co.
Durham Co.	Muskoka Dist.	Victoria Co.
Elgin Co.	Norfolk Co.	Waterloo Co.
Essex Co.	Northumberland Co.	Welland Co.
Grey Co.	Ontario Co.	Wellington Co.
Halton Co.	Oxford Co.	Wentworth Co.
Huron Co.	Parry Sound Dist.	York Co.
Kent Co.	Perth Co.	
<i>Grimmia plagiopodia</i> Hedw.		
Brant Co.	Halton Co.	Peterborough Co.
Bruce Co.	Huron Co.	Prescott Co.
Dufferin Co.	Kent Co.	Simcoe Co.
Durham Co.	Lambton Co.	Welland Co.
Elgin Co.	Middlesex Co.	Wellington Co.
Essex Co.	Norfolk Co.	Wentworth Co.
Grey Co.	Oxford Co.	
Haldimand Co.	Perth Co.	
<i>Grimmia pulvinata</i> (Hedw.) Sm.		
Elgin Co.	Haldimand Co.	
Essex Co.	Prescott Co.	

mia pulvinata was first collected in Ontario in Elgin County on July 11, 1970 (Stewart 877, MICH) on old concrete of a railway culvert. It has subsequently been collected on the Oriskany sandstone formation in Haldimand County (Cook & Stewart 2073, UWO) and on calcareous grave markers in the Counties of Essex and Prescott.

FIELD STUDIES

Since the discovery of *Grimmia plagiopodia* in Elgin County in 1969 (Stewart & Cook 1972), additional collections by the author have resulted in new county records for the genus *Grimmia* in Southwestern Ontario, from Essex County eastward to the Niagara Peninsula (Table 1). Due to the outstanding collecting success experienced in the cemeteries of southwestern Ontario, in 1985-6 this study was expanded to include cemeteries in all of the counties and districts of southern Ontario, south of Hwy. 17 and Lake Nipissing.

During the course of this study, each of the 46 counties and districts of southern Ontario was visited and upwards of 622 cemeteries were searched (Figs. 2-4). A special effort was made to spend additional search time in under-collected counties and areas with low resident population densities,



Figs. 2-4. Maps showing the distribution of *Grimmia anodon* B.S.G. (Fig. 2, top), *Grimmia plagiopodia* Hedw. (Fig. 3, middle), and *Grimmia pulvinata* (Hedw.) Sm. (Fig. 4, bottom) in southern Ontario as determined by this study. Dots represent Counties and Districts where specimens were collected.

such as vacation areas and settlements on the Canadian Shield, where in many cases the quantity of material encountered was very small or non-existent. Conversely, when collecting success was achieved early in a county search, further collecting was abandoned in favour of unrecorded counties, with the result that many cemeteries in counties near the center of abundance of these mosses remain uncollected.

When the on-site data for the bryophyte collections were being recorded, it became apparent that the more mature colonies of *Grimmia* occurred on substrates of great age. When the colony was on a tombstone the age of exposure of the substrate was often indicated by the earliest burial date recorded on the marker and this information was recorded with the specimen.

All collection data was subsequently analysed to provide age, abundance and distributional data for each species.

RESULTS AND DISCUSSION

One of the preferred substrates of *Grimmia anodon* and *G. plagiopodia* in Southern Ontario is Queenston limestone, a pale, grey-brown, homogenous type of limestone quarried in the Niagara Region. This material comprises the majority of the limestone tombstone and grave marker bases in the cemeteries of southwestern Ontario.

In cemeteries northward on the Canadian Shield and in eastern Ontario, the Queenston limestone is largely replaced by Trenton limestone, a blue-grey, somewhat porous substrate with unstable structural characteristics and poor weather resistance. Due to a somewhat different chemical composition (Hewitt 1960), tombstone bases constructed of Trenton limestone were rarely observed to support significant bryophyte growth.

In favourable locations, the colonies of *Grimmia* usually occurred on the upper horizontal ledges of the limestone marker bases, in full sunshine and above the snowline in winter. Colonies in such locations often reached 10 cm² in size and were readily noticed by the collector, but good colonies may also occur at the base of the stone or on the concrete foundation, where in winter they become frozen in ice and snow. *G. anodon* and *G. plagiopodia* were sometimes found growing on substrates close to one another and, in a few cases, mixed colonies were encountered.

A most important factor affecting collecting success was the degree of exposure of the cemetery. Little or no success was encountered in open hilltop cemeteries which were exposed to high winds and the scouring effects of ice and snow. The best collecting success was experienced in cemeteries where ample humidity was present, either due to the proximity of water or in the form of mist or fog. Collecting success was necessarily poor in counties where low population densities require fewer cemeteries and in areas dominated by the acidic rocks of the Canadian Shield. In such areas the problem was often compounded where acidic stone was utilized for markers rather than imported limestone which, in addition to concrete,

constituted most of the substrate available to calciphilic mosses in these areas.

Another, most beneficial factor was the degree of protection afforded by a rolling landscape, or by the proximity of trees or shrubs. Vegetation provided a protected environment or microclimate, increasing moisture levels as well as providing some protection from wind. Such favourable environments were often indicated by the presence of more easily seen saxicolous species such as blackish colonies of *Schistidium apocarpum* (Hedw.) B.S.G. and the bright orange lichen *Xanthoria elegans* (Link) Th. Fr. Other moss associates include *Orthotrichum anomalum* Hedw., *Barbula unguiculata* Hedw., *Ceratodon purpureus* (Hedw.) Brid. and less frequently, *Leucodon brachypus* var. *andrewsianus* Crum & Anders., *Hedwigia ciliare* (Hedw.) P. Beauv. and *Schistidium rivulare* (Brid.) Podp.

In some metropolitan and industrial sectors within the study area, air pollution was suspected to be the significant factor where collecting success was limited. Indeed, in one large cemetery adjacent to a mainline railway, a heavy precipitation of diesel fumes may have been responsible for the absence of lichen and bryophyte growth.

In areas where natural substrates were present, either adjacent to or within a cemetery, these were also searched for *Grimmia* species, but without success. This would render unlikely the possibility that the occurrence of *Grimmia* in these areas was due to the inoculation of cemetery substrates from plants in adjacent natural areas. Since most colonies were encountered in full fruiting condition, their occurrence on the fine textured, often vertical substrates of tombstones suggests that species dispersal within the immediate area is achieved by windborne spores rather than by vegetative means.

The occurrence of these three species of *Grimmia* in restricted habitats in southern Ontario raises a number of interesting questions in regard to their mode of distribution. Conceivably, their occurrence in eastern North America may be the result of airborne spores, transported on updraughts in the mountains of the west and carried eastward by prevailing winds to precipitate at random across eastern North America. The preference of these mosses for very old substrates may be due to changes in the chemical composition of the limestone or an increase in moisture retention due to an enhanced porosity of the stone due to weathering. Many of the more mature colonies of *Grimmia* had become saturated with dust or fine debris which resulted in a crusted appearance and gave the impression of great age. Their occurrence on older substrates could also suggest that these mosses require an extended growth time to become established, but on-site growth studies involving observations of recovery rates at sites where previous collections had been made demonstrated that under favourable conditions, moderately collected colonies can recover satisfactorily in a relatively few years.

When the date of burial data recorded from the tombstones was analysed, it revealed that the substrates which supported colonies of *Grimmia* had an average age of 100 years and were often the oldest stones in the cemetery.

In many agricultural regions in southwestern Ontario where colonies of *Grimmia* were most frequently encountered, the proximity of air-borne fertilizers was considered as a possible factor in the success of these mosses, but evidence is not conclusive. All three species occur in regions of southern Ontario where agriculture is not a dominant feature of the landscape, but in reduced numbers since the lack of suitable substrate is the limiting factor in these areas.

It is interesting to note that none of the three study species of *Grimmia* was encountered on natural substrates in the region of the Niagara Gorge where Queenston limestone outcrops naturally and also is quarried in the area. Since Queenston limestone is a favoured substrate for these mosses in Ontario, the region of the Niagara Escarpment deserves much further study. The apparent absence of these mosses from areas in Ontario where natural outcroppings exist suggests that their habitat preference is critical. Their appearance on modified substrates may coincide with the evolution of suitable habitat due to weathering. The precise dating provided by cemeteries may thus be a useful indication of the date of their establishment in southern Ontario.

Favourable environmental factors and the availability of suitable substrate are most critical for these calciphilic mosses which, despite the success experienced in this study, must continue to be regarded as very rare species in Ontario.

SUMMARY

The many new records for the rare mosses *Grimmia anodon* B.S.G., *G. plagiopodia* Hedw. and *G. pulvinata* (Hedw.) Sm., collected on calcareous cemetery substrates have revealed an interesting pattern of distribution for these mosses in Southern Ontario. The most frequently encountered species was *G. anodon*, collected at 67 sites in 29 Counties and Districts of Southern Ontario. *G. plagiopodia* was collected at 46 sites, representing 22 Counties of Southern Ontario.

The distribution of both *Grimmia anodon* and *G. plagiopodia* followed closely the utilization of Queenston limestone for tombstones and grave marker bases, although both species were occasionally found on plot demarcation walls and old concrete in cemeteries. Both species demonstrated an almost equal radius of distribution from the limestone quarries near Niagara where the commercial Queenston Stone originates. Only a few collections of the above species were recorded from the eastern counties of Ontario, perhaps due to the utilization of the unsuitable substrate, Trenton limestone for grave marker bases and on the Canadian Shield, where acidic cemetery substrates predominated. *G. pulvinata* was much the rarest of the three target species, with only 5 sites from 4 counties in southern Ontario. Site data revealed a rather even but widespread distribution across the southernmost part of Southern Ontario. Curiously, *G. pulvinata* was the only one of the above three species which was encountered in nature, where it was collected on sandstone of the Oriskany formation in Haldimand County. It also occurred on cut limestone blocks and old concrete.

Records show that an average of 9 cemeteries were visited for each collection of *Grimmia* recorded and an average of 14 cemeteries per county were searched. Nevertheless, route planning and time constraints inevitably necessitated some curtailment of collecting activities and renders this study by no means complete. Additional search time in areas with low population densities, especially on the Canadian Shield and in the eastern counties of Ontario will surely increase our knowledge of the distribution of these mosses in Ontario.

The area covered by this study represents only a minor portion of the potential range of these mosses in eastern North America. The previous lack of records for eastern North Amer-

ica may indicate that they are recent arrivals or have been overlooked, since records undoubtedly reflect the activities of collectors as well as the true distribution of the species.

The degree of collecting success experienced during the course of this study indicates that cemeteries can provide easily located, accessible sources for saxicolous mosses and a high concentration of diversified substrates. In southwestern Ontario where rock outcroppings are scarce or non-existent, cemeteries provide the major source for saxicolous species.

The isolation of cemetery substrates as a significant source for these saxicolous mosses presents a major opportunity for both the bryologist and phytogeographer to expand the known distribution of the genus *Grimmia* in areas where it has been previously unsuspected and unknown.

The initial voucher specimens for this study are deposited in the herbarium of the University of Michigan (MICH). Subsequent collections are deposited at the National Museum of Natural Sciences, Ottawa, Canada (CANM), with some duplicates at the University of Western Ontario, London, Ontario (UWO). A complete set of duplicates, except for a few unicates sent to CANM, are in the private collection of the author (WGS).

NOTE

In recent years the boundaries of some of the counties and districts of Ontario have been re-organized with different configurations and some Regional Municipalities have been formed. In the interest of conformity and greater convenience in the locating of collection sites, the older county numbering system as detailed by Ireland and Cain (1975) has been retained for this study.

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Special thanks go to my wife, Eileene, without whose enthusiasm for this project and valuable assistance in the field, the scope of this study would not have been possible.

My sincere thanks are extended to Dr. Howard A. Crum, University of Michigan Herbarium, Ann Arbor, Michigan 48104, for his generous offer to see my initial collections and whose encouragement and advice are much appreciated.

I am also much indebted to Dr. Robert R. Ireland, Curator of Bryophytes, National Museum of Natural Sciences, Ottawa, Canada K1A 0M8, for determining the hundreds of specimens collected in the course of this study and for helpful information on the distribution of *Grimmia* in Ontario.

I am also grateful to Mr. Fred Kristoff, Curator of the Aylmer, Ontario Cemetery, who received specialized training at the Queenston quarry facility, for determining the Queenston substrate.

My thanks also go to Dr. C. Gordon Winder, Department of Geology, University of Western Ontario N6A 5B7, for informative discussions on Queenston limestone and for determining specimens of Trenton limestone.

I wish also to thank the staff of the Cartographic Section of the Department of Geography, The University of Western Ontario, London, Ontario, for information and maps defining the limits of southern Ontario and southwestern Ontario.

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REVIEW

ORCHIDS OF ONTARIO, AN ILLUSTRATED GUIDE. R. E. Whiting & P. M. Catling. 1986. CanaColl Foundation, Ottawa, Canada. 169 pp., 36 figures, including 51 black-and-white photographs plus line drawings; 60 distribution maps. \$12.50 paper.

Orchids of Ontario presents a wealth of information concerning native orchids of Ontario in an attractive layout. To assist the non-orchidologist in interpreting flower structure, the authors provide a brief, but clear, description of those aspects of flower structure used in identifying orchids. Fine line drawings complement the descriptions. A discussion of problems associated with protection of uncommon, rare and threatened species emphasizes the importance of habitat preservation and of resisting the temptation of transplanting individuals to the "protection" of one's own backyard, where death of the plant is the most common outcome. A list of endangered, threatened, rare, and uncommon species is provided.

The book treats taxa and named hybrids that occur in Ontario, as evidenced by at least one herbarium specimen of each taxon found in the many institutional herbaria examined. The authors also acknowledge that "consideration" is also given to published reports and personal communications. How this consideration is used to modify ranges based on herbarium data is not explained.

The 72 species, varieties, and named hybrids are referred to by scientific name and common name, with some synonyms included. An indented, dichotomous key to genera heads the taxonomic section and directs the reader to keys to species within genera containing two or more species. No genus descriptions are included. The keys are well-constructed and include descriptions of from 1 to 4 or, occasionally, 5 or 6 contrasting characteristics per couplet.

Treatment of each species begins with a commentary paragraph relating information about additional distinguishing characteristics, natural history, or pollination biology. Additional information about each species is included under the subheadings flower color, distribution and habitat, flowering time, and remarks. In most cases, references to the literature are given. The habitat descriptions should be very helpful to those wishing to observe native orchids in the wild and clearly reflect the authors' extensive experience.

Distribution maps of all species are printed at the end of the book in the sequence of appearance of the taxa in the text. Given the non-alphabetical arrangement of taxa, I would have preferred that the maps be printed adjacent to each species' treatment or in an alphabetical arrangement at the end of the book. Dots on the maps represent localities documented by specimens; other symbols indicate localities referred to in the literature only. Line drawings and excellent black and white photographs grace the treatments of many species.

A checklist of names is included near the end of the book, along with an interesting annotated list of taxa that the authors consider likely to occur in Ontario but that have not been reported as occurring in the province recently. A convenient flowering time chart offers a visual summary of flowering times of all taxa, as taken from labels of herbarium specimens collected from all parts of each taxon's range. Such data are suspect due to biases introduced by collectors who search for particular species during the time when those species are assumed to be in flower. This chart overcomes some of this difficulty by including the number of specimens upon which the flowering times are based. Larger numbers of specimens examined increases one's confidence in the flowering time data. The authors' field observations on flowering times supplement herbarium label data.

A 9-page Literature Cited section caps the work and provides ready access to much literature that might otherwise be overlooked by American botanists in particular.

The general layout and appearance of the book is very attractive, even though, for obvious time and cost savings, the text is typewritten. Justified margins improve the appearance of the text. It appears to be free of typographical errors. Reproduction of all photographs is well done and appears to have done justice to the originals. Distribution maps are very attractive and are presented in three scales, depending on the geographic distribution of the taxon shown. In some cases more detailed distributions could have been shown if larger-scale maps had been available.

In summary, this book is an attractive and well-produced work that belongs in the library of any botanist or natural historian interested in orchids of the Great Lakes region. It contains a wealth of information and references to the literature that can serve as a starting point for continuing studies of the many aspects of orchid biology and biogeography discussed by the authors.

—Gary L. Hannan

PUBLICATION OF INTEREST

MANUAL OF CULTIVATED BROAD-LEAVED TREES & SHRUBS, Vol. III, Pru-Z. 1978 (1986-English Translation) Gerd Krüssmann, Translated by Michael E. Epp. Timber Press, Portland, Oregon, \$65.00; \$195 for 3-volume set (Vol. I:A-D, Vol.II:E-Pro; Vol.III:Pru-Z). For those of us who routinely work with a variety of cultivated plants, Krussmann's 3-volume work is a remarkable compendium of taxonomic information. Although the three volumes have some frustrating drawbacks, overall, the wealth of information available in one source overrides most of the problems one encounters.

The volumes are organized alphabetically by genus, making retrieval of information on a specific genus an easy matter. But the organization on specific and subspecific levels is inconsistent and at times difficult to sort through. Some of the treatments have "keys", although only a small number of genera throughout the whole set have true keys. For the most part, "keys" are sectional listings of names, followed by descriptions of each species. The larger genera are treated in this fashion. If you are not familiar with the whole genus, figuring out your unknown can be tedious and time-consuming. Another difficulty is the incomplete listing of cultivars. But a complete listing of all the cultivars in all cultivated broad-leaved trees and shrubs would occupy many volumes. Also, although the volumes are profusely illustrated, there is not a definitive illustration for each genus, a feature I find helpful in some floristic treatments.

Volume I contains a glossary and zone maps for the U.S., Canada, Europe, and China; Volume III contains the zone maps and several appendices, including an author index, addenda to Volume I, and a taxonomic outline of the genera covered in the set. There is no index to the set, which would be useful since only the genera are listed in alphabetical order.

Overall, the work despite some frustrating shortcomings, is very welcome as it does provide a wealth of taxonomic, phytogeographic, and horticultural information in one reference.

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POA BULBOSA L. (POACEAE) IN MICHIGAN

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Poa bulbosa L., a Eurasian endemic, is now listed in local floras as occurring in at least half of the conterminous 48 states. It has been recently discovered in Vermont (Zika 1986) and Massachusetts (Grayum & Rohman 1986). It is widespread and generally more common in the Northwest where Halperin (1933) frequently found it in cultivated fields. Kennedy (1929) felt that it had been introduced to the United States with alfalfa seed.

Recently, it has been found in urban lawns and disturbed areas in Michigan. The first known collection in Michigan was R. B. Willson s.n. (MSC acc. #256209)¹!, 11 May 1961 from a lawn on Morley Street in Flint, Genesee Co. Subsequent collections include A. A. Reznicek #5062, 30 April 1979, in Washtenaw Co. (MICH)!; A. A. Reznicek #6655, 11 May 1982, also in Washtenaw Co. (MICH)!; and my own collections from Ingham Co.: G.F.G. #616, 15 May 1986 (MSC)! and G.F.G. #636, 25 April 1987 (MSC)!, both from the same population. This species is not reported in Voss (1972) and I believe that this is the first published report of its occurrence in Michigan.

This perennial grass is easily recognized by the bulbous and often reddish bases of the culms and the replacement of most of the spikelets by apomictically produced bulbils (Fig. 1). Bulbils are small bulb like propagative structures produced in the inflorescences of many species of plants.

Some European and Middle Eastern material apparently does not normally produce bulbils and there has been a tendency in early European literature to recognize many infraspecific taxa in *Poa bulbosa* to differentiate specimens that have differing degrees of replacement of spikelets by bulbils (see Edmondson 1980). Although Younger (1960) showed that there is considerable evidence for a number of ecotypes in this species, he also showed that the percentage of spikelets being replaced by bulbils is largely affected by the environment. Because of this and the relative homogeneity of the material collected in Michigan I feel that it would not be useful to recognize infraspecific taxa in our material.

¹Accessioned into the permanent collection of (MSC) 22 June 1980.

²The "!" shows that this collection was examined by the author.



Figure 1: Inflorescence of *Poa bulbosa* showing bulbils.

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I thank Dr. E. G. Voss for taking the time to search his records for me, Dr. S. N. Stephenson for helpful comments, Dr. J. H. Beaman for the use of facilities and continued advisement, and the many curators of herbaria holding material from Michigan who responded to my letters on this subject.

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245 PHOSPHATE ADSORPTION BY CEDAR WETLAND SOILS IN NORTHERN LOWER MICHIGAN

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Vegetation, microorganisms, and soil contribute to inorganic phosphorus retention in a wetland. However, because stored phosphate is released into the water during vegetational decay and microorganisms have a limited ability to utilize phosphate, wetland soils are often considered a significant long-term phosphate sink (Nichols 1981; Richardson 1985; Richardson & Marshall 1986).

Cedar wetland soils can be either mineral or organic (or a mixture of both) and undergo a variety of conditions throughout the year. In the spring, under characteristically wet conditions, the soil is saturated and anaerobic. During summer, declining water levels permit aerobic conditions in surficial layers of soil. Soil pH may range between 6.0–7.4. Schwintzer (1981) found 40 mg/L calcium, one of the principal minerals reactive with phosphate, in shallow groundwater of cedar wetlands in northern lower Michigan.

The objective of this study was to evaluate the potential for cedar wetland soils to improve water quality by removing orthophosphate from water draining a watershed. Phosphate adsorptive abilities were compared among soils of nine cedar wetlands in northern lower Michigan at three different phosphate concentrations.

MATERIALS AND METHODS

The nine wetlands sampled in this study occurred in low lying areas on outwash and lake plains and on old lake beaches contiguous to existing lakes, in Emmet and Cheboygan counties in northern lower Michigan (Table 1). Sites varied in size from 3.0 to 210 ha. Each of the sites was directly connected to the hydrology of its local watershed by groundwater or surface water flow. Creeks flowed through five sites and three sites were contiguous to lakes. At the sites without surface water flow, the water table was visible or could be found within 20–30 cm of the soil surface, even during the dry periods of August.

Cedar wetland sites were located by their vegetational characteristics. Northern white cedar (*Thuja occidentalis* L.) dominated the wetland sites sampled. The abundance and type of plant species of cedar wetlands described by Schwintzer (1981) was similar to the plant composition in the wetlands sampled in this study. One wetland, Reese's Swamp served as a site in both studies.

Soil samples from each site were collected in one of two ways, depending on the morphology of the wetland. Narrow sites with a prominent natural feature, such as a pronounced slope or a creek, were divided into a grid of 5-m squares. Nine random squares were then sampled.

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TABLE 1. Location and approximate size of cedar wetlands examined.

Site	Location	Approximate Size (ha)
1	R.5.W., T.37.N., SE 1/4 Sec. 8, SW 1/4 Sec. 9	33.0
*2	R.3.W., T.36.N., Sec. 3,4	210.0
3	R.5.W., T.37.N., NE 1/4 Sec. 9	6.3
4	R.5.W., T.37.N., NE 1/4 Sec. 17	2.3
5	R.4.W., T.37.N., SW 1/4 Sec. 19, NW 1/4 Sec. 30	3.0
*6	R.1.W., T.38.N., NE 1/4 Sec. 25, R.1.E., T.38.N., N 1/2 Sec. 30	13.0
7	R.4.W., T.37.N., SE 1/4 Sec. 32, R.4.W., T.38.N., NE 1/4 Sec. 5, NW 1/4 Sec. 4	4.0
8	R.6.W., T.36.N., Sec. 7	7.9
9	R.5.W., T.36.N., NW 1/4 Sec. 21	9.8

*Site 2 is Reese's Swamp; Site 6 is known as Grass Bay Swamp. All other sites are unnamed.

For larger, more circular wetland sites, the center of the wetland was located using a topographic map. Three compass bearings were randomly chosen to serve as transect directions from the center. Soil was collected with a soil auger to a depth of 20 cm at three random distances on each transect. Nine samples were collected at each wetland site, thoroughly mixed into three composite samples, and used to assay phosphate adsorption. Samples were stored at 4°C.

Field-wet soils (20 cm³) were exposed to 100 ml of phosphate (KH₂PO₄) solution: 0.0 (controls), 76, 382, and 764 µg PO₄³⁻/L. These concentrations parallel those found in surface water runoff reported in the literature. Soluble PO₄³⁻ in urban stormwater has been found to range from 100–1000 µg/L (Wanielista 1977). Donigian (1977) reports total phosphorus concentrations from agricultural cropland between 20 and 1700 µg/L and between 10 and 110 µg/L from forested land.

The samples were stirred every 15 minutes for 10 seconds. After three hours, the samples were gravity filtered through Whatman #4 filters. After one hour the filtrate was filtered through a glass fiber filter and prewashed (soaked overnight in distilled water and rinsed ten times) 0.45-µm pore diameter filter. Orthophosphate was measured colorimetrically with a spectrophotometer using a 10-cm pathlength following the procedure described in Wetzel and Likens (1979). Phosphate lost from the initial solution was considered adsorbed by the soil.

The percent phosphate adsorbed was calculated from the final phosphate concentrations to allow comparison between wetland sites. Percentages could not be calculated with the controls and were not used in this statistical analysis. The percentages were transformed into the arcsine square root to achieve a close approximation of a normal distribution (Sokal & Rolf 1981). A two-way, nested analysis of variance (ANOVA) was calculated on the transformed data. Variation in soil adsorption between wetland sites and between the initial phosphate concentrations were the major effects tested with the ANOVA. The variance of the three composite samples (variance within wetland sites) was tested as a subgroup of the two main factors.

RESULTS AND DISCUSSION

The overall mean of phosphate adsorbed for all samples, in all the wetland sites, and for all added phosphate concentrations was 90% (Figure 1). The 0.05 confidence interval fell between 87% and 93%. Means from all but two sites were in the 90 percentile range, with adsorption ranging from 67% to 96% (Figure 1a). The means of phosphate adsorbed at each site were sufficiently different to produce a significant ($p > 0.001$) variation, primarily as a result of the lower value at Site 5. The percent phosphate adsorbed between samples (variance within a wetland site) is also significantly different ($p > 0.001$) (Figure 1c). The soils may adsorb different amounts of phosphate based on concentrations of exchangeable calcium. However, the soils share similar physical characteristics. Table 2 provides a description of each soil series found at the nine sites sampled (Soil Conservation Service, 1973; Soil Conservation Service, in preparation). The soils fell into two major categories: black loam sand and black muck. Both types have sand subsoils.

All soils can become saturated with phosphate, a phenomenon recorded in both laboratory (Bache & Williams 1971; Hammer & Kadlec 1980; Sawhney & Hill 1975) and natural systems (Nichols 1983). Comparison of the phosphate concentrations removed in experiments of the present study (variation between initial phosphate concentrations) indicated that a saturation point had not been reached. Phosphate adsorption was not significantly different between the low (76), medium (382), and high (764 $\mu\text{g PO}_4^3\text{-L}$) means (Figure 1b). This response indicates that soils adsorbed similar percentages of phosphate at any of the initial concentrations added.

Figure 1c illustrates the distribution of initial phosphate concentration means by wetland sites. Most points fell near the overall mean. Soil from Site 5 adsorbed the least amount of phosphate. No pattern between low, medium, or high concentrations was observed among the wetland sites.

Phosphate adsorption on many soil types has been studied extensively. Batch experiments on Muskegon dune sand resulted in 55% phosphate adsorbed (Novak & Petschauer 1979). Comparing cedar wetland soils to other wetland soils, Richardson (1985) found that a swamp forest silt loam (coarse-loamy, siliceous, acid) adsorbed nearly 100% phosphate (with an initial concentration of 33 mg $\text{PO}_4^3\text{-P/L}$). Tawas muck and a Houghton fen (Michigan) peat adsorbed approximately 95% and 79% phosphate, respectively. Extremely acidic Pocosin peats from North Carolina bogs adsorbed 25% phosphate, considerably less than the high pH swamp soils. Not all researchers agree that acid peats have poor adsorptive capacities. Hammer and Kadlec (1980) report 73% phosphate adsorbed for a sedge willow peat. Noting the similarities of phosphate adsorption between aluminum substituted peat and acid soils, Bloom (1981) determined that phosphate was strongly adsorbed to Al-peat in a pH range of 3 to 6.

Several characteristics of cedar wetlands provide the potential for phosphorus retention. The wetlands tend to occur on a shallow (< 100 cm) mixture of mineral and organic soils with a circumneutral pH at ground-

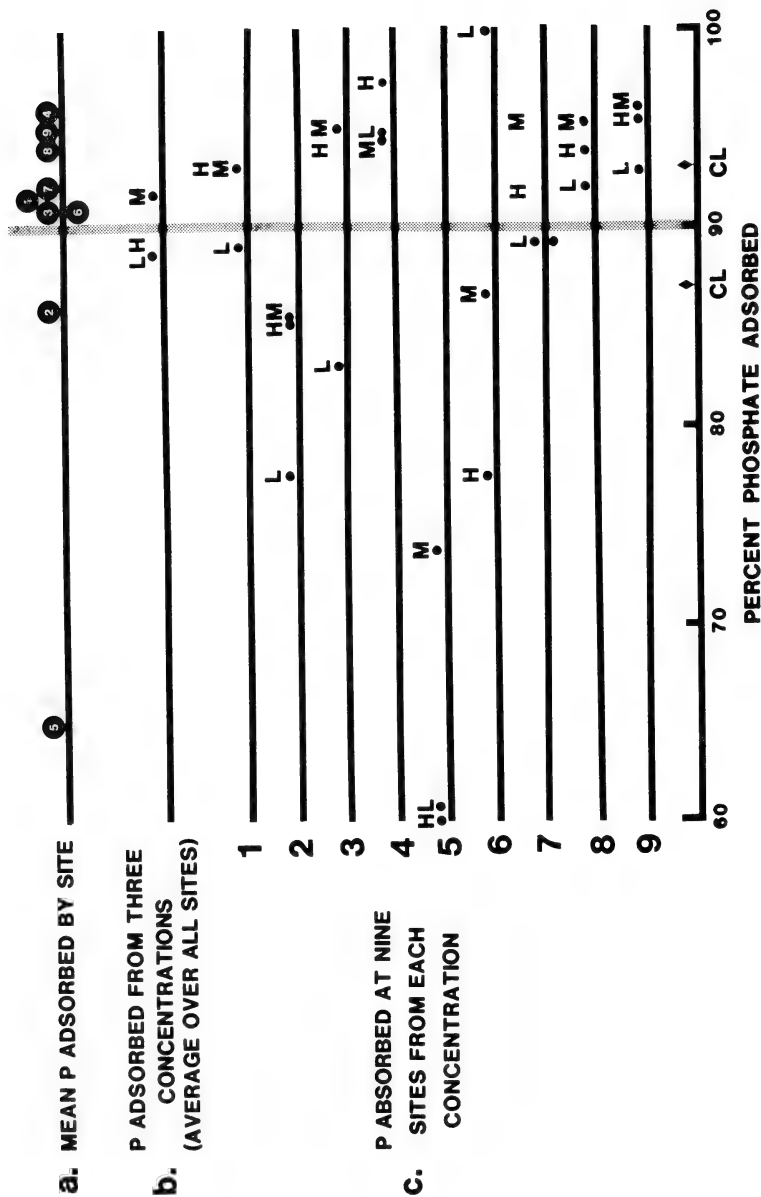


Fig. 1. Mean percent phosphate adsorbed under different conditions. a. Mean phosphate adsorbed by site ($n = 9$ per site). b. Mean phosphate adsorbed from three initial enrichments pooled from all sites. L = 76, M = 382, H = 764 $\mu\text{g PO}_4^{3-}/\text{L}$. c. Mean percent phosphate adsorbed by site. The vertical gray line denotes the overall mean for all sites, all samples, and all initial concentrations. CL denotes the 0.05 confidence limit of the overall mean.

TABLE 2. Description of soil series found in every wetland site sampled. The number of sites each soil series was found is also given.

Series	Descriptions	Number of Sites Found
Au Gres (gravelly subsoil variant)	Black loamy sand over a grayish-brown loamy sand with dark grayish-brown mottled subsoil	2
Brevport	Black, mucky, loamy sand over dark grayish-brown loamy sand mottled with brown subsoil	1
Carbondale	Black muck over a dark grayish-brown muck subsoil	1
Linwood	Black muck over dark brown muck subsoil	1
Roscommon	Very dark brown mucky sand over a light brownish grey sand subsoil	2
Tawas	Black muck over very dark grey muck subsoil	4
Wheatley	Black loamy sand over light, brownish-grey, loose loamy sand, then brown loose loamy sand subsoil mottled with yellowish brown	

water discharge areas or along streambanks (Novitzki 1978). Near neutral pH and high calcium concentrations suggest that phosphate reacts principally with calcium. Groundwater flows into the wetland and the parent bedrock may be an important source of dissolved calcium. The black muck and black loamy sand (sapric to hemic) found in many of the wetlands have a low hydraulic conductivity, making water movement relatively slow, which undoubtedly enhances phosphorus adsorption. Hydraulic conductivity measurements from two wetland sites in this study (Reese's Swamp and Grass Bay) ranged from 0.000055–0.00018 cm/s. Mitsch and Gosselink (1986) report the hydraulic conductivity of hemic soils ranging from 0.000012–0.00150 cm/s compared to limestone at 0.00005 cm/s and sand at 0.05 cm/s.

The hydrology of many cedar wetlands may limit phosphate adsorption, despite the ability of soil to adsorb large quantities of phosphate. Comparison of cedar wetlands with emergent wetlands may not be appropriate. Surface water tends to flow through a cedar wetland in relatively distinct channels that may wind extensively through the wetland, not in a sheetflow pattern often seen in emergent wetlands. Contact with the soil may not occur without extensive flooding or sheetflow through the wetland. Relatively little is known about wetland hydrology and it represents one of the largest gaps of knowledge in wetland ecology (Mitsch & Gosselink 1986; Greeson et al. 1978).

SUMMARY

Phosphate adsorptive abilities were compared among soils of nine cedar wetlands in northern lower Michigan. Soils were tested at three phosphate concentrations. The overall mean of phosphate adsorbed for all wetland sites and initial concentrations was $90 \pm 3\%$ (CI 0.05%, $n = 81$) of phosphate added. Phosphate adsorption among and within wetland sites varied significantly. Soils adsorbed similar percentages of phosphate at all concentrations assayed with little indication of saturation.

ACKNOWLEDGMENTS

I thank the University of Michigan Biological Station and Tip of the Mit Watershed Council for financial assistance and their staffs for technical support and encouragement. I am particularly grateful to Douglas Deutschman for his unfailing enthusiasm in the field and expert statistical knowledge.

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ALEXANDER H. SMITH

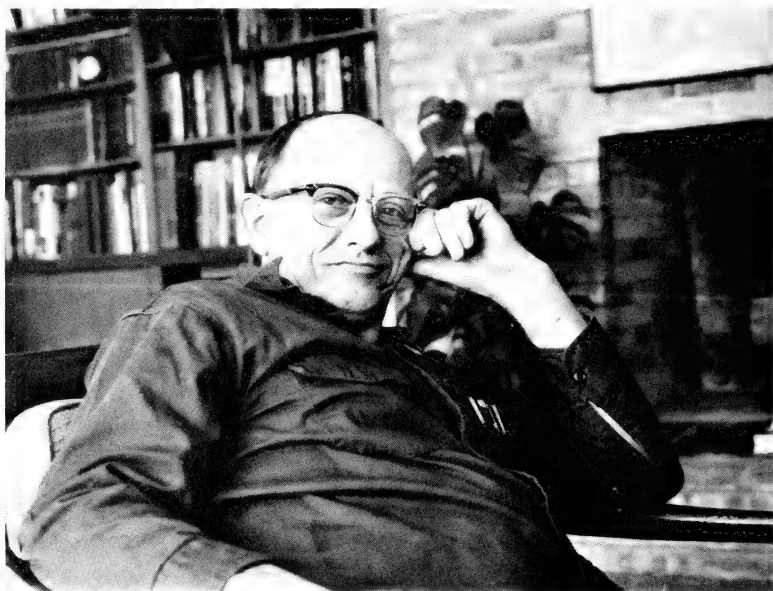
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"Mr. Mushroom" was the designation by the distinguished mycologist moderating the session at the Second International Mycological Congress as he introduced Alexander H. Smith. There were gentle chuckles of recognition and concurrence. Significantly the topic was "Mycology and the Layman," and Dr. Smith discussed the role of the amateur in mycology. The venue and speaker were appropriate, but while professionals in the audience were reminded of the synergism of working with amateurs they were not initiated into the more subtle aspects of "high-grading." Few professionals have contributed as much to mycology and none has done more to promote the mutualistic symbiosis of professionals and amateurs in the study of mushrooms.

Alexander Smith's academic career, from graduate degrees to a vigorous emeritus professorship, the latter in no way a retirement, was spent with the University of Michigan (Table 1). He was born December 13, 1904, in Crandon, Wisconsin, and received his elementary and high school education in Crandon and West DePere, graduating from high school in 1923. He proceeded to Lawrence College in 1924, where he served as an undergraduate assistant for three years, and received his bachelor's degree in Arts in 1928. Summer, 1928, at "Bug Camp," the University's Biological Station, started his 58-year association with the University of Michigan. That singular affiliation did not delimit the loci of his activities, as may be noted from the list of his forays initiated individually and with various professional and amateur organizations. Most were shared with Dr. Helen V. Smith, whom he married in 1936. The trips are listed (Table 2) not only to document their extent but also to jog pleasant memories for companions and local hosts. The strategy and adventures of many of those trips were recalled by Helen Smith in her introductory article in the *Festschrift* honoring Alexander Smith's seventieth birthday [Bigelow, H. E., & H. D. Thiers, eds., *Studies on Higher Fungi*, Nova Hedwigia 51, 1975]. Their collaboration was graced with a daughter, Nancy Jane [Weber], and they shared other authorships and honors, which are listed (in Table 3). Near the end illness slowed him down but did not keep him down, and the neighborhood sustained mini-forays with an unused wheelchair trundled behind. He died at home December 12, 1986.

Alexander Smith's impressive list of publications is extracted below (Table 4). In *Mushrooms in Their Natural Habitats*, 1949, with photos by William B. Gruber, he exploited then-available special visual technology, stereoscopic transparencies, to supplement written descriptions of mush-



Alexander H. Smith at home.

rooms. Were he starting the project today, one can imagine his using holograms or high-resolution computer graphics. The book and transparencies, even today and in out-of-print reprints, remain collectors' items. Another special visual presentation is the *Mushroom Book*, with John Cage and Lois Long. While Captain McIlvaine can properly be credited with this country's first popular mushroom book, Alexander Smith and *The Mushroom Hunter's Field Guide*, led the way for the present cohort of mushroom books for the general public. With the current pervasive dependence of academic science on federal funding, it is significant that sale of the MHFG was originally conceived as source of support for herbarium research. The University of Michigan Press and Graduate School ceremonially noted the 100,000th copy. *The Mushroom Hunter's Field Guide* is in its third edition with the collaboration of daughter Nancy Weber and has spawned regional extensions, *A Field Guide to Western Mushrooms* and *A Field Guide to Southern Mushrooms*, the last-named also with Nancy. The whole family collaborated on *How to Know the Gilled Mushrooms* and . . . *Non-Gilled Fleshy Fungi*. The mycology in Alexander Smith's books and papers is obvious, but one should also savor his way with English. The early, less elaborate *Some Common Mushrooms of Michigan's Parks and Recreation Areas*, was written with Helen, and the sales rights given to the Michigan Botanical Club to further its activities. Support for the Botanical Club is

TABLE 1. Degrees and Positions Held by Alexander H. Smith at The University of Michigan

M.A., 1930; Ph.D., 1933
Cole Fellow in Botany, 1932
Research Assistant, University Herbarium, 1932-4
Assistant Curator, University Herbarium, 1934-40
Associate Curator, University Herbarium, 1940-5
Associate Professor of Botany, 1945-56
Botanist, University Herbarium, 1945-59
Professor of Botany, 1956-75
Director, University Herbarium, 1959-72
Deputy Director, Biological Station, 1968
Professor Emeritus of Botany, 1975-86

TABLE 2. Major Field Trips by Alexander and Helen Smith.

1931: Nova Scotia, Canada*
1934: Adirondack Mountains, NY*
1935: Olympic Peninsula, WA; Lake Takenitsch, OR; Trinidad, CA*
1936: Lake Timagami, ON, Canada*
1937: Great Smoky Mountains, TN; Blue River, OR; Crescent City, CA; Grants Pass—Cave Junction, OR
1938: Great Smoky Mountains, TN
1939: Olympic Peninsula, WA; Great Smoky Mountains, TN
1941: McCall, ID; North Cascades, WA; Olympic Peninsula, WA; Sisters, OR
1944: Mt. Hood, OR
1946: McCall, ID; Mt. Hood, OR
1948: Mt. Rainier, WA
1950: Medicine Bow Mountains, WY
1952: Mt. Rainier, WA
1954: McCall, ID; Mt. Rainier, WA
1956: San Juan Mountains, CO; McCall, ID; Priest Lake, ID; Grants Pass, OR; Orick, CA
1958: McCall, ID
1959: Quebec, Canada*
1960: Taunton, England
1962: McCall, ID
1964: Priest River Experimental Forest, ID; McCall, ID
1966: Priest River Experimental Forest, ID
1968: Priest River Experimental Forest, ID
1970: Scotland; Priest River Experimental Forest, ID; Cascade Head Experimental Forest, OR; San Francisco, CA
1971: Europe: Belgium, Switzerland, England, The Netherlands
1972: Priest River Experimental Forest, ID; Randel, WA; Pacific City, OR
1973: Amherst, MA; ME
1976: Europe: Switzerland
1974-1981: Snowmass Village, CO
1986: last foray, 1986 Smith Lake States Foray, Oct. 4 Circle Pines Camp, Barry Co., MI

*without Helen

TABLE 3. Service and Distinctions

Editor, <i>Mycologia</i> , 1945-50
Mycological Society of America: President, 1950; Distinguished Mycologist Award, 1982
British Mycological Society: Guest Mycologist, Taunton Foray, England, 1960
Michigan Academy of Science, Arts and Letters, President, 1966-7
North American Mycological Association: Award for Contributions to Amateur Mycology & Honorary Life Member, 1968; honoree, Alexander and Helen Smith Foray, Granby, CO, 1983
Symposium Honoring L.R. Hesler on his 80th Birthday, Knoxville, TN: invited participant, 1968
Botanical Society of America, Certificate of Merit, 1969
Tricentennial of Royal Botanic Garden, Edinburgh: official representative of Univ. of Michigan, 1970
Science Seminar Series, Joint Center for Graduate Study; Oregon State Univ., Washington State Univ., Univ. of Washington: invited participant, 1970-1
Research Club of the Univ. of Michigan, President, 1974-5
Michigan Botanical Club: President, Huron Valley Chapter, 1974-5; [State] Vice President, 1950-2; [State] President, 1957-9; Editorial Board, <i>The Michigan Botanist</i> , 1962-72; Director, 1983-6
Honorary Life Member (with H.V. Smith)
Michigan Natural Areas Council, Chairman, 1952-3, 1961-2
Aspen Conferences on Mushroom Poisoning: Senior Mycologist 1974-81
Univ. of Michigan Press and Graduate School: honoree, special convocation, 1975
Symposium Herbet, Lausanne: invited participant, 1976
Colorado Mycological Society, Honorary Member (with H.V. Smith)
Michigan Mushroom Hunters' Club, Honorary Member
Oregon Mycological Society, Honorary Member (with H.V. Smith)
West Michigan Mycological Society, Honorary Member

also seen in numerous articles in *The Michigan Botanist*, membership on its editorial board, and service as President of the Huron Valley Chapter, State President, and on the Board of Directors. He presided in several other organizations including the Mycological Society of America; Michigan Academy of Science, Arts and Letters; Research Club [of the University of Michigan]; and the Michigan Natural Areas Council. He made a particular contribution in bringing mushrooms to the general public and in leading some of them into serious study and devoted mushrooming, specifically through his role in the establishment of the North American Mycological Association and in nurturing the efforts of many local clubs and countless individuals. It is not inaccurate to say he became a "cult-figure." His service and mycologic endeavors were recognized with many and significant honors.

TABLE 4. Books and Separate Monographs.

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- Fungi of Southeastern Michigan*. Cranbrook Institute of Science, Bull. 14, 1938
- North American Species of Mycena*. Univ. of Mich. Press, 1947.
- Mushroom in Their Natural Habitats* (photos by William B. Gruber). Sawyer's Inc., 1949.
- Puffballs and Their Allies in Michigan*. Univ. Mich. Press, 1951.
- The Mushroom Hunter's Field Guide*. Univ. Mich. Press, 1958, 1963, (with N.S. Weber) 1980.
- North American Species of Hygrophorus* (with L.R. Hesler*). Univ. Tenn. Press, 1963.
- Some Common Mushrooms of Michigan's Parks and Recreation Areas* (with H.V. Smith). Mich. Bot. Club Special Publ. 1, 1963.
- A Monograph on the Genus Galerina Earle* (with R. Singer). Hafner & Co., 1964.
- A Contribution Toward a Monograph of North American Species of Suillus* (with H.D. Thiers). Published privately, 1964.
- Keys to the Genera of Higher Fungi* (with R.L. Shaffer). Univ. Mich. Biol. Sta., 1964.
- North American Species of Crepidotus* (with L.R. Hesler*). Hafner & Co., 1965.
- The North American Species of Pholiota* (with L.R. Hesler). Hafner Publ. Co., 1968.
- The Boletes of Michigan* (with H.D. Thiers). Univ. Mich. Press, 1971.
- Mushroom Book* (with J. Cage* & L. Long). Hollanders Workshop, 1972.
- How To Know The Non-Gilled Fleshy Fungi* (with H.V. Smith & [2nd ed] N.S. Weber). Wm. C. Brown Co., 1973, 1981.
- A Field Guide To Western Mushrooms*. Univ. Mich. Press, 1975.
- How To Know The Gilled Mushrooms* (with H.V. Smith & N.S. Weber). Wm. C. Brown Co., 1979.
- North American Species of Lactarius* (with L.R. Hesler*). Univ. Mich. Press, 1979.
- The Veiled Species of Hebeloma in the Western United States* (with V. Evanson & D.H. Mitchel). Univ. Mich. Press, 1984
- A Field Guide to Southern Mushrooms* (with N.S. Weber*, photos by D. Guravich). Univ. Mich. Press, 1985.
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*Asterisk denotes senior author.

The mycologic publications and even the honors are not the full measure of Alexander Smith. Scanning the titles and noting the co-authors, one can recognize former graduate students, visiting scholars, and other collaborators who are significant figures in mycology in North America and world-wide. His role as a teacher can be seen not only in his students but also the students' students, including the many more whose only matriculation has been to carry a mushroom basket. It is a tremendous legacy, for which we can only say "Thank you, Alex."

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

C. JOURNAL ARTICLES (continued from vol. 26, p. 175).

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- Barnes, Burton V., Kurt S. Pregitzer, Thomas A. Spies, & Vera H. Spooner. 1982. Ecological forest site classification. *Jour. For.* 80: 493–498. [Site classification of the Natural Area of the McCormick Experimental Forest used for illustration.]
- Barnes, Burton V., & Bruce P. Dancik. 1985. Characteristics and origin of a new birch species, *Betula murrayana*, from southern Michigan. *Canad. Jour. Bot.* 63: 223–226. [An octoploid derivative from the pentaploid *B. ×purpusii* described from Third Sister Lake, Washtenaw Co.]
- Barnes, Burton V., & Kurt S. Pregitzer. 1985. Occurrence of hybrids between bigtooth and trembling aspen in Michigan. *Canad. Jour. Bot.* 63: 1888–1890. [General survey of number and abundance of clones in southeastern and northern Lower Peninsula and western Upper Peninsula, but with no distribution map of the hybrid.]
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- Cairns, John, Jr., James L. Plafkin, Roger L. Kaesler, & Rex L. Lowe. 1983. Early colonization patterns of diatoms and protozoa in fourteen fresh-water lakes. *Jour. Protozool.* 30: 47–51. [All lakes were in vicinity of University of Michigan Biological Station.]
- Dancik, Bruce P., & Burton V. Barnes. 1974. Variability of yellow birch in the western Great Lakes region. *Proc. Northeast. For. Tree Improvem. Conf.* 21: 42–48. [Populations were studied from throughout the Lower Peninsula and eastern Upper Peninsula.]
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- Dancik, Bruce P., & Burton V. Barnes. 1975. Multivariate analyses of hybrid populations. *Nat. Canad.* 102: 835–843. [Study of *Betula ×purpusii* and its parents at Walsh Lake, Washtenaw Co.]
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- Dickinson, T. A. 1985. The biology of Canadian weeds. 68. *Crataegus crus-galli* L. sensu lato. *Canad. Jour. Pl. Sci.* 65: 641–654. [Distribution map for Canada and northeastern U.S. indicates county records in Michigan and neighboring states (but without county—or state—boundaries shown).]
- Evans, Francis C. 1986. Bee-flower interactions on an old field in southeastern Michigan. *Proc. N. Am. Prairie Conf.* 9: 103–109. [Phenology of bee visitations to a number of species on the E. S. George Reserve.]

- Furlow, John J. 1987. The *Carpinus caroliniana* complex in North America. I. A multivariate analysis of geographical variation. *Syst. Bot.* 12: 21–40. [Material used included specimens from Houghton and East Lansing.]
- Futyma, Richard P., & Norton G. Miller. 1986. Stratigraphy and genesis of the Lake Sixteen peatland, northern Michigan. *Canad. Jour. Bot.* 64: 3008–3019. [Study in Cheboygan Co., based largely on pollen analysis.]
- Haber, Erich. 1983. Morphological variability and flavonol chemistry of the *Pyrola asarifolia* complex (Ericaceae) in North America. *Syst. Bot.* 8: 277–298. [Includes all eastern N. A. material in one spp., *asarifolia* (varieties not considered taxonomically useful); distribution map has 6 or 7 dots in Michigan, without county lines.]
- Hardin, James W., & Lyle L. Phillips. 1985. Atlas of foliar surface features in woody plants, VII. *Rhus* subg. *Rhus* (Anacardiaceae) of North America. *Bull. Torrey Bot. Club* 112: 1–10. [SEM views of *R. typhina* from Genesee and Washtenaw counties; *R. glabra* \times *typhina* said to be “particularly noticeable along roads and edges of woods in southern Michigan.”]
- Haynes, Robert R. 1985. A revision of the clasping-leaved Potamogeton (Potamogetonaceae). *Sida* 11: 173–188. [Distribution maps indicate occurrence of *P. richardsonii* and *P. praelongus*, but not *P. perfoliatus*, in Michigan, though without state or county lines shown. Lectotype of *P. richardsonii* from “Michigan” [Ontonagon River in 1862], Robbins.]
- Hausen, B. M., H. W. Schmalte, D. Marshall, & R. H. Thomson. 1983. 5,8-Dihydroxyflavone (primetin) the contact sensitizer of *Primula mistassinica* Michaux. *Arch. Dermatol. Res.* 275: 365–370. [Analysis of a potential allergen based on material supplied from Emmet and Cheboygan counties; confusion results from misidentification of source for an earlier report from the Chicago region—cf. correction in same journal 277: 157.]
- Hellquist, C. Barre, & Robert L. Hilton. 1983. A new species of Potamogeton (Potamogetonaceae) from northeastern United States. *Syst. Bot.* 8: 86–92. [Specimens from Black River, Cheboygan Co., confirmed as *P. \times longiligulatus* and not the new *P. ogdenii*, which is close to *P. hillii* (and not known from Michigan).]
- Hellquist, C. Barre, & Garrett E. Crow. 1986. *Potamogeton* \times *haynesii* (Potamogetonaceae), a new species from northeastern North America. *Brittonia* 38: 415–419. [Type from Presque Isle Co., with other material cited from Cheboygan, Emmet, St. Clair, Schoolcraft, Van Buren, and Washtenaw cos.; the taxon was previously known as *P. longiligulatus*, a name placed in synonymy of *P. strictifolius*.]
- Hess, William H. 1986. *Wolffia papulifera* Thompson (Lemnaceae), new to Michigan. *Sida* 11: 407–411. [Discovered in Berrien Co.]
- Hix, David M., & Burton V. Barnes. 1984. Effects of clear-cutting on the vegetation and soil of an eastern hemlock dominated ecosystem, western upper Michigan. *Canad. Jour. For. Res.* 14: 914–923. [Study plots were along the boundary of the Sylvania Recreation Area, Gogebic Co.]
- Hudson, William D. 1984. Vegetation profiles from color-infrared airphotos. *Mich. Academ.* 16: 301–313. [Pilot studies in Delta Co. and across a longer transect in Antrim, Otsego, and Montmorency cos., integrating vegetation types with topography and soils.]
- Koerper, Greg J., & Curtis J. Richardson. 1980. Biomass and net annual primary production regressions for *Populus grandidentata* on three sites in northern lower Michigan. *Canad. Jour. For. Res.* 10: 92–101. [Includes data on composition and structure of the tree strata in the stands, all in Cheboygan Co.]
- Křisa, Bohdan. 1966. Contribution to the taxonomy of the genus *Pyrola* L. in North America. *Bot. Jahrb. Syst.* 85: 612–637. [Discusses primarily *P. asarifolia*, of which two subspecies occur in Michigan: ssp. *asarifolia* and ssp. *americana*, the latter placed by most authors with *P. rotundifolia*; ssp. *americana* cited from Cheboygan Co.; only characters in the key are strongly overlapping measurements and it is hence useless, and there is no mention of major differences in color and phenology.]
- Kyhos, Donald W., & Peter H. Raven. 1982. Miscellaneous chromosome numbers in Astera-ceae. *Madroño* 29: 62. [Includes count of $2n = 54$ for *Tanacetum huronense* from southwest of Mackinaw city (erroneously attributed to Cheboygan Co., corrected to Emmet in same journal 29: 274. 1982), with thoughts on relationships of this species to circumpolar plants and those of the Pacific coast.]

- Les, Donald H., & Ronald L. Stuckey. 1985. The introduction and spread of *Veronica beccabunga* (Scrophulariaceae) in eastern North America. *Rhodora* 87: 503-515. [Four known Michigan collections mapped and cited (in chronological order of collection, 1924-1958).]
- Les, Donald H. 1985. The taxonomic significance of plumule morphology in *Ceratophyllum* (Ceratophyllaceae). *Syst. Bot.* 10: 338-346. [Distribution map shows 8 stations in Michigan for *C. echinatum* (no county lines) and one of the voucher specimens for plumule studies was from the state; two vouchers from "Michigan" for *C. demersum*.]
- Lowry, Porter P., II, & Almut G. Jones. 1984. Systematics of *Osmorhiza* Raf. (Apiaceae: Apoideae). *Ann. Missouri Bot. Gard.* 71: 1128-1171. [Includes key, descriptions, citations of selected specimens, and distribution maps, the latter with major errors indicating species some 200 miles out of range in Michigan: *O. depauperata*, which is in fact known from the state only from Isle Royale and Manitou Island off the tip of the Keweenaw Peninsula, is mapped and cited from Leelanau County although the label of the cited specimen clearly says Keweenaw Co.; *O. chilensis*, in fact not known in the state south of Leelanau and Alpena counties, is mapped and cited from Wayne Co., although the specimen itself had been confirmed by the senior author as *O. claytonii*.]
- Mellichamp, Larry. 1982. Field studies on CP at UMBS. *Carnivorous Pl. Newsl.* 11: 10-11; 13; 28. [General comments, plea for study and research, color photos.]
- Mulligan, Gerald A., & Derek B. Munro. 1981. The biology of Canadian weeds. 48. *Cicuta maculata* L., *C. douglasii* (DC.) Coult. & Rose and *C. virosa* L. *Canad. Jour. Pl. Sci.* 61: 93-105. [Distribution map for *C. maculata* includes a few dots in Michigan.]
- Philbrick, C. Thomas, & Gregory J. Anderson. 1987. Implications of pollen/ovule ratios and pollen size for the reproductive biology of *Potamogeton* and autogamy in aquatic angiosperms. *Syst. Bot.* 12: 98-105. [Some of the material of three species of pondweed came from cited Michigan localities.]
- Pippen, Richard W., & Kim Alan Chapman. 1986. Comparison of morphological characters between regional habitats of *Cacalia plantaginea* (Asteraceae). *Proc. N. Am. Prairie Conf.* 9: 34-43. [Includes county distribution map; Bois Blanc Island is northernmost site known for the species.]
- Pleznac, Christine. 1983. Michigan cemetery prairies and their flora. *Proc. N. Am. Prairie Conf.* 8: 130-132. [General discussion, with mention (but no list) of some species.]
- Pregitzer, Kurt S., & Burton V. Barnes. 1982. The use of ground flora to indicate edaphic factors in upland ecosystems of the McCormick Experimental Forest, upper Michigan. *Canad. Jour. For. Res.* 12: 661-672.
- Pregitzer, Kurt S., Burton V. Barnes, & Gary D. Lemme. 1983. Relationship of topography to soils and vegetation in an upper Michigan ecosystem. *Soil Sci. Am. Jour.* 47: 117-123. [Study in the McCormick Experimental Forest, Marquette Co.]
- Pregitzer, Kurt S., & Burton V. Barnes. 1984. Classification and Comparison of upland hardwood and conifer ecosystems of the Cyrus H. McCormick Experimental Forest, upper Michigan. *Canad. Jour. For. Res.* 14: 362-375.
- Rabeller, Richard K. 1985. *Petrorhagia* (Caryophyllaceae) of North America. *Sida* 11: 6-44. [Maps Michigan locations of *P. saxifraga* and *P. prolifera*, and cites selected specimens, with historical remarks.]
- Randall, John L., & Khidir W. Hilu. 1986. Biosystematic studies of North American *Trisetum spicatum* (Poaceae). *Syst. Bot.* 11: 567-578. [Conclusion does not support recognition of infraspecific taxa; distribution map of specimens used in the numerical analysis includes two dots on mainland of Lower Peninsula, which must surely be based on misreading of labels. Several erroneous author citations given for the infraspecific taxa not recognized.]
- Reznicek, A. A., & P. M. Catling. 1986. The status and distribution of *Carex subimpressa* (Cyperaceae). *Canad. Jour. Bot.* 64: 227-232. [Taxon to be considered a good species rather than a hybrid, mapped only from Monroe County in Michigan, from which three collections are cited; material previously identified from Gratiot County referred to *C. lacustris* × *C. lanuginosa*.]
- Rosatti, Thomas J. 1987. Field and garden studies of *Arctostaphylos uva-ursi* (Ericaceae) in North America. *Syst. Bot.* 12: 61-77. [Concludes that named variants within the species are not worth recognizing; map of natural populations studied indicates much material from Michigan, where plants intermediate between varieties occur.]

- Semple, John C., & JoAnne Ford. 1981. The phylogeography of leaf morphology in two species of North American asters, *Lasellea novae-angliae* and *L. oblongifolia* (Compositae). *Brittonia* 33: 517–522. [Distribution map shows that all Michigan material examined had leaves in the narrowest category for New England aster—for which the correct name, if not left in the inclusive genus *Aster*, is apparently *Virgulus novae-angliae*.]
- Semple, John C., Gordon S. Ringius, Colleen Leeder, & Gary Morton. 1984. Chromosome numbers of goldenrods, *Euthamia* and *Solidago* (Compositae: Astereae). II. Additional counts with comments on cytogeography. *Brittonia* 36: 280–292. [Includes counts based on Michigan material for *E. graminifolia*, *E. remota*, *S. gigantea*, *S. ohioensis*, *S. patula*, and *S. uliginosa*.]
- Sokal, Robert R., Theodore J. Crovello, & Robert S. Unnasch. 1986. Geographic variation of vegetative characters of *Populus deltoides*. *Syst. Bot.* 11: 419–432. [Size and shape of leaves and twig size from 302 localities, including 8 in Michigan, analyzed and mapped.]
- Spies, T. A., & B. V. Barnes. 1981. A morphological analysis of *Populus alba*, *P. grandidentata* and their natural hybrids in southeastern Michigan. *Silvae Genet.* 30: 102–106. [Study of *P. ×rouleauiana* and its parents in Jackson, Washtenaw, and Livingston cos.]
- Spies, Thomas A., & Burton V. Barnes. 1982. Natural hybridization between *Populus alba* L. and the native aspens in southeastern Michigan. *Canad. Jour. For. Res.* 12: 653–660. [Observations in Jackson, Washtenaw, and Livingston cos.]
- Spooner, David M., Allison W. Cusick, George F. Hall, & Jerry M. Baskin. 1985. Observations on the distribution and ecology of *Sida hermaphrodita* (L.) Rusby (Malvaceae). *Sida* 11: 215–225. [Map of historical distribution includes dots in Kalamazoo and Wayne counties—although no specimen evidence is cited for the former; species is assumed to be indigenous in Michigan. There are said to be two Farwell “specimens” from Wayne Co.; in fact, there are two Farwell collections, each known from three sheets.]
- Stephenson, Stephen N. 1983. Maxton Plains, prairie refugia of Drummond Island, Chippewa County, Michigan. *Proc. N. Am. Prairie Conf.* 8: 56–60. [Study of both pavement and grassland communities.]
- Stuckey, Ronald L., & Guy L. Denny. 1981. Prairie fens and bog fens in Ohio: floristic similarities, differences, and geographical affinities. pp. 1–33 in *Geobotany II* (ed. Robert C. Romans). [Up-to-date distribution maps for N. A. include dots in Michigan for *Sarracenia purpurea*, *Tofieldia glutinosa*, *Cladium mariscoides*, *Potentilla fruticosa*, *Lobelia kalmii*, *Valeriana ciliata*, *Zigadenus glaucus*, *Gentiana procera*, *Cirsium muticum*, *Cypripedium reginae*, *Pedicularis lanceolata*, *Agalinis purpurea*, *Liatris spicata*, *Scleria verticillata*.]
- Stuckey, Ronald L. 1983. Absence of certain aquatic vascular plants from the Prairie Peninsula. *Proc. N. Am. Prairie Conf.* 8: 97–104. [Distribution maps for eastern N. A. include Michigan dots for 11 marsh and aquatic species.]
- Thomasson, Joseph R. 1986. Lemma epidermal features in the North American species of *Melica* and selected species of *Briza*, *Catabrosa*, *Glyceria*, *Neostapfia*, *Pleuropogon*, and *Schizachne* (Gramineae). *Syst. Bot.* 11: 253–262. [One specimen of *M. smithii* studied was from Cheboygan Co.]
- Thompson, Paul W. 1983. Composition of prairie stands in southern Michigan and adjoining areas. *Proc. N. Am. Prairie Conf.* 8: 105–111. [Consists principally of a chart listing 204 species and the 26 prairies from which they have been observed.]
- Thompson, Paul W., & Joseph E. Jaworski. 1986. Flora of Lime Lake Fen Spring Arbor, Michigan. *Proc. N. Am. Prairie Conf.* 9: 58–60. [List of species, with numerous typographical and nomenclatural errors, from site in Jackson Co.]
- Voss, Edward G., & Richard E. Riefner, Jr. 1983. A pyralid moth (Lepidoptera) as pollinator of blunt-leaf orchid. *Great Lakes Entomol.* 16: 57–60. [Observations in northern Michigan.]
- Wagner, Warren L. 1983. New species and combinations in the genus *Oenothera* (Onagraceae). *Ann. Missouri Bot. Gard.* 70: 194–196. [*O. clelandii* described as new, the type from Mason Co., collected by Charles Barclay—to replace what has long been misidentified as *O. rhombipetala*.]
- Waterway, Marcia J. 1986 A reevaluation of *Lycopodium porophyllum* and its relationship to *L. lucidulum* (Lycopodiaceae). *Syst. Bot.* 11: 263–276. [Localities in Menominee and Alger counties are cited among sources of population samples of *L. lucidulum*. Distribution map of this species has dots throughout Michigan (no counties indicated).]

- Jour. Radioanalyt. Chem. 71: 97–113. [Aquatic plants sampled from Huron Mountains and several sites around Saginaw Bay; some species were better than others at accumulating ions of heavy metals.]
- Winsor, James. 1983. Persistence by habitat dominance in the annual *Impatiens capensis* (Balsaminaceae). Jour. Ecol. 71: 451–466. [Study area was on grounds of the Univ. Mich. Botanical Gardens.]
- Woodland, Dennis W., I. John Bassett, Cliff Crompton, & Suzanne Forget. 1982. Biosystematics of the perennial North American taxa of *Urtica*, I. Chromosome number, hybridization, and palynology. Syst. Bot. 7: 269–281. [Includes chromosome count on *U. dioica* ssp. *gracilis* from Berrien Co.]
- Woodland, Dennis W. 1982. Biosystematics of the perennial North American taxa of *Urtica*, II. Taxonomy. Syst. Bot. 7: 282–290. [Distribution map includes Michigan dots for *U. dioica* ssp. *gracilis* but not for ssp. *dioica* although a collection of the latter is cited and designated as “lectotype” of *U. gracilis* var. *latifolia* Farwell—a designation already made in 1953 by McVaugh, Cain, and Hagenah.]
- Zech, James C. 1987. Micromorphological characteristics of the tegumen layer among three Michigan species of *Luzula* (Juncaceae). Ohio Jour. Sci. 87(2): 5. [abstract]

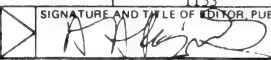
PUBLICATION OF INTEREST

THE NEW SAVORY WILD MUSHROOM, By Margaret McKenny & Daniel E. Stuntz. Revised and enlarged by Joseph F. Ammirati. 1987. University of Washington Press, Seattle. 249 pp. Paper, \$12.50; clothbound, \$25.00. This is the third edition of what has become a classic in the Pacific Northwest. Despite the emphasis on western species, well over three-quarters of the 200 species included are found in the Great Lakes region. The photographs are excellent and well chosen, demonstrating distinguishing field characters very accurately. This is fortunate as identifications will have to be made on macroscopic features alone. There are no keys and the brief descriptions are non-technical. Boletes and other non-gilled fungi are treated on the basis of fruiting body types. The gilled mushrooms are arranged by genera according to spore color from light to dark and alphabetically within the genus. Both common and Latin names are given for each species along with comments on edibility.

There is a succinct, updated section on mushroom toxicology, including a rarely found consideration of toxic heavy metals absorbed by otherwise edible mushrooms. While not guaranteeing absolute safety, the discussion of hazards should go far to discourage even the most avid “pothunter” from any mushroom not positively identified. Matching a specimen in hand using only photographs is risky at best and at worst deadly.

This is an attractive book, well arranged; and earlier editions have been much loved for their simplicity by beginning foragers. They, of course, are exactly the group most apt to get into trouble using the picture-matching approach, even with some of the best mushroom pictures among recent publications. This book would be a reasonably priced addition to a library of mushroom reference books, but not as a sole source of information nor substitute for a more comprehensive field guide.

—Martha W. Cochran

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On the cover: *Naturalist Eileen Stewart examining a colony of Grimmia anodon B.S.G. on the limestone base of a grave marker in a cemetery at Hamilton, Ontario.*
Photo by W. G. Stewart, 25 May 1987.

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245 A RESEARCH GARDEN FOR SELECTED MICHIGAN RARE PLANTS

James R. Wells

Cranbrook Institute of Science,
Bloomfield Hills, MI 48013

In the spring of 1987 the first plantings for research purposes were made in a garden in Birmingham devoted to the study of Michigan's uncommon species of plants, i.e., those on the list of endangered, threatened, special concern and other novelties which, for want of categorical characterization might be termed "rare" species (Beaman et al. 1985). Although gardens, or portions of gardens, for growing such plants exist elsewhere including Harvard University's Arnold Arboretum (Jamaica Plain, MA 02130 (617) 524-6988), and the Holden Arboretum, (9500 Sperry Rd., Mentor, OH 44060 (216) 946-4400), this is the first of its type, known to the writer, in Michigan, for Michigan plants collected in Michigan. Nationally, one of the larger projects is located at the National Wildflower Research Center in Texas, (2600 Farm to Market Rd. 973 North, Austin TX 78725 (512) 929-3600).

Approximately four years ago a 2 1/2-acre garden, residence for the caretaker, and endowment were bequeathed to Cranbrook Educational Community by the late Maja Schjolin (pronounced: show-leen). The garden is known as the Schjolin Plant Conservation Garden. Although the garden's name might imply conservation in the strictest sense of the term, its main purpose is to study the plants rather than to "save" them. The process of *saving* rarities in the U.S. is headquartered at the Center for Plant Conservation, c/o Arnold Arboretum, with some 18 regional gardens located throughout the U.S. The Holden Arboretum is the official representative for the Great Lakes region which includes Michigan.

A meandering branch of the Rouge River bisects the floodplain into an open sunny area and a shaded sector. Eastward from the floodplain a steep 30-ft. slope opens out into a mature oak-hickory forest. Trails and steps are available to all sections of the garden. The donor's long-term interest in both native and cultivated plants is wonderfully blended in an ideal garden site which one visitor characterized as "carefully wild". Among the many kinds of plants contained in the garden is the national champion spindle tree or eastern burning-bush (*Euonymus europeus* L.). Its champion-determining dimensions are: height 32 ft.; crown spread 29 ft.; and girth measured at 4 1/2 ft. above ground level is 22 in. (Thompson 1986).

Situated in a small cove on a north-facing slope is a garden devoted to the cultivation of pteridophytes. This garden is planted and maintained by Ethelda Hagenah and Joyce Drife along with her husband, Don. Numerous plantings of ferns occur elsewhere throughout the garden. Some ferns are

hybrids—unique to science—and were created by the late Dale Hagenah in collaboration with Dr. W. H. Wagner, Jr. of the University of Michigan.

Specific objectives for the garden, for the foreseeable future, are:

- 1) To provide a single location wherein many species of Michigan's uncommon, threatened, endangered, and otherwise rare vascular plants can be grown and studied;
- 2) To offer research opportunities for professional scientists, university students, and other qualified investigators in such disciplines as plant genetics, systematics, ecology, and pollination biology;
- 3) To serve as a genetic bank harboring Michigan's rarest species and providing withdrawals of plant material by qualified persons for laboratory, greenhouse, or other *ex situ* research projects;
- 4) To provide a place of temporary or permanent refuge, even on short notice, for individual plants of uncommon species which are adversely affected by construction or other habitat obliteration;
- 5) To maintain garden areas ideally adapted to selected species of Michigan's flora, nurturing a source of irreplaceable plants which may represent unique ecotypes and which may be reintroduced into suitable natural habitats.

A detailed site plan has been drawn by Cranbrook's landscape architect and horticulturist, Ralph Mize. Modifications to selected areas will be made to prepare specific environments and ready the garden for additional plantings of species uncommon in Michigan. In this controlled plan, there will be a gradual decrease in emphasis upon horticultural species and an increased attention to research devoted to Michigan's native and naturalized flora based upon the strict guidelines as outlined above.

Only a few kinds of plant habitats are planned; namely, open sun, shady floodplain, and upland oak-hickory woodland. No effort will be made, for example, to develop a bog or pond for plants requiring those conditions. Raised flower beds will be constructed in each of the habitat types.

All plants collected for use in the garden have been obtained with the necessary permit from the Michigan Department of Natural Resources. Only *Michigan* endangered, threatened, special concern, or rare species will be included. The plant materials must have come from native or naturalized localities within Michigan. Plant donations to this collection will be generally discouraged and when accepted must have been collected in accordance with state and federal law.

Specimens of plants on the Michigan list of endangered and threatened species (Beaman et al. 1985, or its authorized successive editions) may not be collected without necessary permission as authorized by the Michigan Endangered Species Act, Act 203, P.A. 1974. Questions concerning Threatened Plant Collector's Permit for plants which would be used for scientific purposes *only* should be addressed to the Michigan Department of Natural Resources, Endangered Species Coordinator, Wildlife Division, Box 30028, Mason Building, Lansing, MI 48909, telephone (517) 373-9333. Formal reports of all collections requiring this permit must be filed with the Depart-

ment of Natural Resources at the end of the single year for which each permit is issued.

Further, in order to transport rooted plants, even common ones, from one location to another, e.g., as close as one city block, they *must* be inspected for disease and insect pests. This applies to bare-rooted plants or plant parts, not including seeds. Provision for this inspection is provided by the Insect and Plant Diseases Law, Act 189, P.A. 1931 and is administered by the Michigan Department of Agriculture. For questions concerning this law the reader can contact the Michigan Department of Agriculture, Pesticide and Plant Pest Management Division (formerly the Plant Industry Division), P.O. Box 30017, 611 W. Ottawa, North Tower, 4th Floor, Lansing, MI 48909, telephone (517) 373-1087. A number of regional offices are located throughout the state and their addresses and telephone numbers are shown below along with the jurisdictional boundaries of each region (Fig. 1). Through each regional office are employed several inspectors with each inspector having a defined area of involvement within that region. Those intending to have inspections made of plant materials should, if possible, notify the pertinent regional office a few days prior to the time that living plants are to be moved.

Michigan Department of Agriculture Consumer Protection Bureau Regions

Region 1

Room 117
State Office Building
Escanaba, MI 49829
(906) 786-5462

Region 2

Bldg. 42, Apt. 132
701 S. Elmwood Ave.
Traverse City, MI 49684
(616) 947-3171

Region 3

State Office Building
350 Ottawa, N.W.
Grand Rapids, MI 49503
(616) 456-6988

Region 4

Saginaw State Office Bldg.
411-F East Genessee
Saginaw, MI 48607
(517) 771-1778

Region 5

4032 M-139, Bldg. 116
St. Joseph, MI 49085
(616) 428-2575

Region 6

1615 S. Harrison Rd.
East Lansing, MI 48823
(517) 383-8782

Region 7

1120 W. State Fair
Detroit, MI 48203
(313) 368-2230

It will be the intention of the Cranbrook Institute of Science in its administration of the Schjolin Plant Conservation Garden to network our efforts with state and national organizations having a common interest. Of course, the Michigan Department of Natural Resources and the Michigan Natural Features Inventory will be kept apprised of our work. Outside of the state we will cooperate in every possible way with the Center for Plant

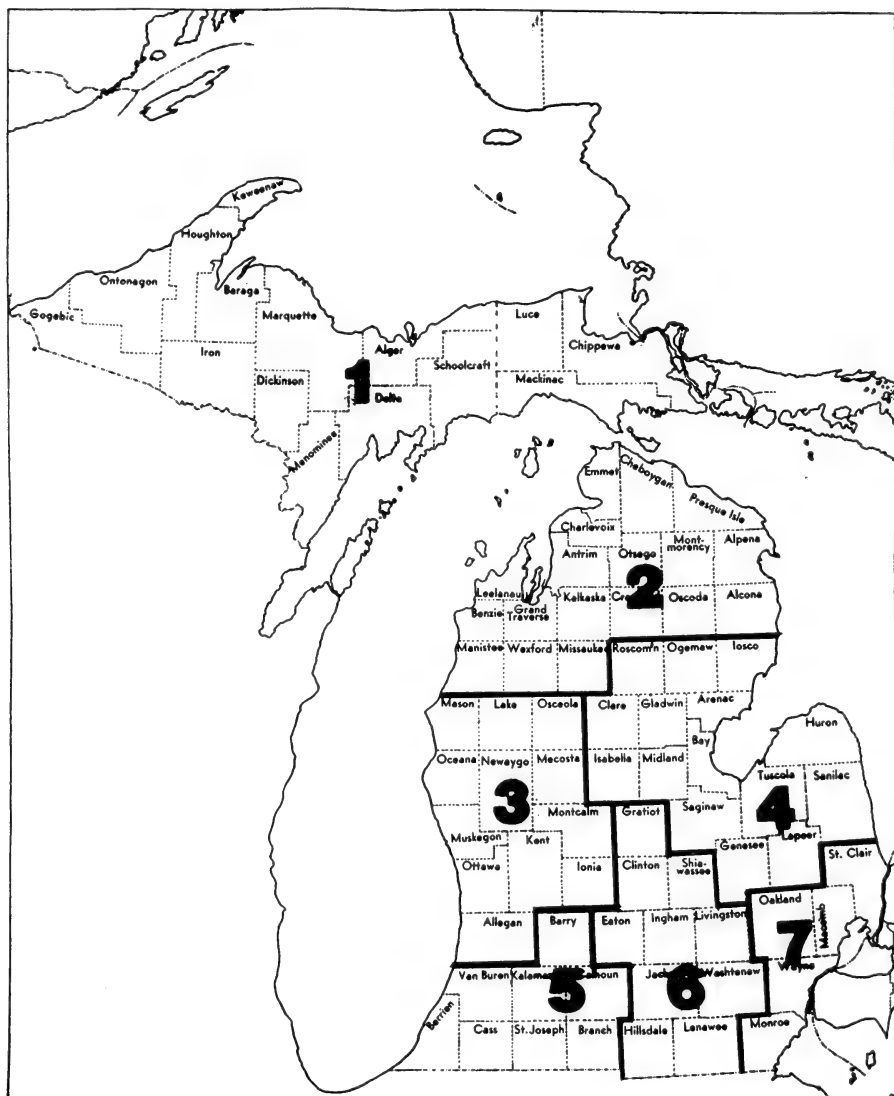


Fig. 1. Map of Michigan showing regional boundaries, Michigan Department of Agriculture, Pesticide and Plant Pest Management Division, (1/87, redrawn).

Conservation at the Arnold Arboretum. The Center operates as a cooperative agency for 18 botanical gardens and arboreta in the U.S. It also serves as a seed storage facility of the U.S. Department of Agriculture. The regional office encompassing the Great Lakes area is the Holden Arbore-

tum in Mentor, OH. We have been in contact with its administration concerning our plans.

This research effort represents a major commitment by the Cranbrook Institute of Science. It is conceivable that future years will see similar gardens appear in other localities within Michigan—sites offering different kinds of habitats and different climatic regimes. Such gardens will offer opportunities to researchers for frequent and convenient contact with plant research materials.

Visitations to the garden are strictly controlled by the administration of the Cranbrook Institute of Science. The garden is in a residential community of Birmingham, MI near Big Beaver and Woodward Avenue. Being in private ownership by Cranbrook, there are, necessarily, liability concerns about the casual walk-on visitor(s). Moreover, with research projects in place the visitor(s), limited to groups of 12 or fewer, must have a guide to help avoid accidental damage to research plants.

The garden has already benefited from volunteer labor from a number of individuals and organizations including the Boy Scouts, Junior League of Birmingham, Cranbrook volunteers, and university students. Critical advice was received from my colleague, Ralph Mize, and from Professors Benninghoff, Wagner, Voss, and Reznicek of the University of Michigan and from Michigan State University Professors Stephenson and Donnelly. Financial support has made possible the implementing of site plans very early in the development phase. Special recognition is due Edna Newnan, Ethelda Hagenah, and Frank's Nurseries for their financial assistance and in-kind gifts.

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Falk, D. A. & F. R. Thibodeau. 1986. Saving the rarest. *Arnoldia* 46: 2–18.
Thompson, P. W. 1986. Champion trees of Michigan. *Michigan Bot.* 25: 112–120.

SIXTH MIDWESTERN BRYOLOGICAL FORAY BLACK RIVER FALLS, WISCONSIN 16–18 SEPTEMBER 1988

The Sixth Midwestern Bryological Foray will be held at Black River Falls, Wisconsin, located on an ancient glacial lake bed adjacent to the unglaciated Driftless Area of southwestern Wisconsin. Nearby are Black River State Forest and extensive peatlands, the center of the state's cranberry and peat moss industries. We will collect the rich bryophyte flora in deciduous and coniferous forests, wetlands, and on limestone and sandstone. Motel accommodations will include a meeting room and all meals.

For more information, contact: John A. Christy, Bryological Foray, Botany Section, Milwaukee Public Museum, 800 West Wells St., Milwaukee, WI 53233

REVIEWS

THE ILLUSTRATED FLORA OF ILLINOIS: DIATOMS. By J. Jeffrey Dodd. Southern Illinois University Press, Carbondale and Edwardsville. 1987. 490 pp., illustrated. \$40.00.

It seems rather strange to be called upon to review a first state flora in 1987. In order to understand why this is necessary, and the potential importance of the work, it is necessary to know a little of the history of research on the particular group of organisms treated.

Investigation of diatoms did not begin until development of modern light microscopes. Once this technology became available, study of microorganisms in general, and diatoms in particular, became one of the "cutting edges" of science during the period between ca. 1830 and 1910. The field attracted a number of investigators with truly prodigious energy and talent who produced a rich and eclectic literature, some of which is only being rediscovered today. Unfortunately, nearly all these early workers were either wealthy "gentlemen scientists" or research scientists working in directly supported state academies. Hence, they trained few students and failed to establish a tradition of study, particularly in North America.

For a long period of time following, research on diatoms was only carried forward by a few individuals, mostly European, mostly self-trained and usually working in isolation. Although many of these individuals made substantial contributions, particularly in purely descriptive work, their major floristic treatises tended to employ highly artificial classifications and often rather idiosyncratic approaches to nomenclature. Beginning in about 1960 this situation changed radically. The availability of increased resolution of morphological characters provided by electron microscopes allowed investigators to demonstrate that some elements of previous classifications were clearly untenable. At the same time, the growth of ecological and paleoecological studies increased the need for reliable information on diatom biology and classification.

As a result of this history, floristic literature on diatoms is strongly bimodal. The very extensive early literature is bridged to a burgeoning modern primary literature by relatively few European floras produced during the 1930's and 1940's. Patrick and Reimer's as yet incomplete *Diatoms of the United States* remains the only modern comprehensive floristic treatise on North American diatoms. There, thus, exists an unfilled need for comprehensive regional works that are available and accessible to students and other nonspecialists.

Dodd's book takes square aim at this need. The approach he adopts is modeled after floras of the generation past, and in this lies both the strength and weakness of his effort. *Diatoms* is written in a clear and conversational style and is clearly intended to be useful to people with little or no previous experience in diatom identification. Basic introductions to diatom biology, classification, collection, preservation, and preparation techniques, and light microscopy are included as appendices. Dodd also provides a complete glossary, including illustrations of morphological terms. Descriptions and keys are brief but lucid, and illustrations are generally of good quality. Small but clear distribution maps are included for all of the taxa that Dodd actually observed in his own field work. In this regard it should be noted that Dodd's actual study was restricted to the inland waters of Illinois—he did not investigate the large marginal rivers or Lake Michigan, although reports of other authors are given in a separate section. Dodd even treats some additional genera "expected" to occur in the state.

Although *Diatoms* will be a delight to students and professional nonspecialists, it is bound to provoke a few groans from specialists in the field. This largely results from the fact that it has a curious "dated" quality. It does not reflect most, even well-agreed, nomenclatural changes made after ca. 1970 and Dodd avoids information and terminology developed from electron microscopy. For example, the . . . "dashlike mark of *Thalassiosira fluviatilis*" is the labiate process of *T. weissflogii* in modern rendition. Numerous other examples could be cited. Suffice it to say that reference to this book relieves no one of responsibility to consult the recent primary literature. Those looking for an "authoritative source" may be disappointed, but they are doomed to disappointment in any case. It is important to realize that there is not now, nor is there likely to be in the near future, a floristic work on diatoms with the same degree of completeness and authority expected of similar works on flowering plants or other well studied groups.

Despite some limitations, I have no doubt that *Diatoms* will be widely used, and perhaps over-used, since it provides the best, and indeed only, comprehensive treatment of the central

North American diatom flora currently available. I recommend it highly as an entrée to study of this diverse and ecologically important component of the aquatic flora. Let us hope it helps inspire the further work necessary to raise the standard of diatom taxonomy generally.

—Eugene Stoermer

THE TREES OF NORTH AMERICA. By Alan Mitchell. Illustrated by David Moore. Facts on File Publications, New York, NY. 1987. 208 pp. \$24.95 hardbound.

This book, by the duo which produced *The Complete Guide to Trees of Britain and Northern Europe*, is an illustrated guide to native and cultivated trees of the contiguous United States and adjacent Canadian provinces. The richly colored drawings usually include leaves, fruit, and sometimes flowers for angiosperms; needle arrangement and cones for gymnosperms. Most show the bark texture and open field form of mature trees. Range maps and winter silhouettes are found in the reference section in the back of the book which also includes sections entitled: "Suitable Trees for the Garden", "Planting a Tree", "Pruning and Shaping", "Improving Growth of Young Trees", and "Measuring Tree Height". The text accompanying the illustrations emphasizes economic and landscaping uses of different tree species and the locations of large cultivated trees rather than technical descriptions useful in identifying them.

Michigan readers should be pleased that a few specimen trees growing in the Beal Gardens at Michigan State and in Hidden Garden, Tappen [Hidden Lake Gardens, Tipton?] are mentioned. Our 1972 National Champion mountain-ash (*Sorbus decora*) and red maple (*Acer rubrum*) are also noted. In the willow section (p. 8) we learn that "in the National Register of Big Trees, 1978 edition, 11 out of the 18 species growing in the eastern states have champion trees in Michigan and 10 of the 14 in the west are in Oregon. This probably owes more to the presence of a particularly zealous champion-hunter in each state than to any growth conditions particularly favourable to willows, but it is some indication in that direction".

The book might find its best use as a beginner's book on trees, or as a quick reference to species not native to our region. Similar species are compared on facing pages and the amateur botanist should be able to find most of the trees occurring in a local park or arboretum. Stories of a nearly lost Japanese cherry, the introduction of Dutch elm disease to North America, and the etymological relationship of maples, planes, and sycamores make interesting reading. Non-botanists will even enjoy looking at the pictures.

The book, however, does not always meet the criteria of highly trained botanists. One wonders why the conifers are placed between dicots and monocots, and why the sycamores (Platanaceae) were placed between the hawthorns and mountain ashes (both Rosaceae). A closer harmonization of the text and illustrations is needed, especially for European species on this side of the Atlantic. Species illustrated in *Trees of Britain and Northern Europe* such as *Prunus avium* and *Fraxinus excelsior* are labelled in *Trees of North America* as wild cherry and common ash, but are neither wild nor common on our continent. In like vein, *Betula pendula* is illustrated as silver birch, but is described under European white birch in the text. For *Ginkgo biloba* (p. 122) we read, "it is neither a broadleaved, 'flowering' tree, or conifer", yet in the illustrations we find its "male catkins" and "female flowers"! We know that the absence of flowers is one character separating gymnosperms from angiosperms, but male and female flowers of several conifers are illustrated and even referred to in the text.

The book has a few minor problems which do not interfere with its use as a reference book. In the index, the indenting of long lists (e.g. cedar and pine) is confused. Redundancies pop up in the text usually in place names which include a state such as "Missouri BG, St. Louis, MO". A key to the two-letter postal abbreviations copiously used in the text has been provided, but Canadian provinces were omitted and non-North American sites (e.g. American Samoa, Guam) were included. The reader should bear in mind that PQ is Quebec, not a typo for PA, Pennsylvania.

Taken as a whole, this book would best be used as a guide to recognizing trees rather than a tool to identifying them.

—B. T. Hazlett

"MINI-COURSES" IN NATURAL HISTORY OFFERED AT THE UNIVERSITY OF MICHIGAN BIOLOGICAL STATION JUNE, 12-17, 1988

We began offering mini-courses specifically designed for UMBS Alumni four years ago in response to many requests. If you'd like to recapture the feeling of being a student at the Biological Station, then the mini-courses are for you! You've probably remembered your summer(s) at UMBS more times than you can count. The simple life close to nature, the physical pleasure of being in the field, the intellectual pleasure of challenging your mind, and the friendly atmosphere can be yours again for five concentrated "8:00-5:00" days. That's equivalent to two and a half weeks of a course during the regular season!

Whether you're a practicing or retired biologist, participating in a mini-course could be just the diversion you need to round out your biological expertise and add it to your resume, or you can attend for the pure pleasure of it. Either way, you're invited to come and know firsthand that the quality of Bug Camp still exists and is available for you to sample. At the close of the course you'll feel once again that your life is changed in a positive way. Hope to see you there.

There will be three courses offered this year. Each is to be taught by an excellent teacher who is well acquainted with the Biological Station and the northern Michigan region. The Biological Station is an especially exciting place for naturalists in June. The northern ecosystems are fresh, clean and very active after the long winter, and interesting biologically. If you want to learn more about these courses (described below), write or call the Biological Station at the address and phone number given below. Approximate costs for five full days of high quality instruction plus room and board, and laboratory and transportation fees, will be a modest \$225.00.

The University of Michigan Biological Station
2043 Natural Science Building
Ann Arbor, MI 48109-1048
Phone (313) 763-4461

Ferns and Fern Allies of the Upper Great Lakes Region—Herb Wagner

Professor Warren H. (Herb) Wagner is a nationally known, highly respected scientist and teacher. A member of the National Academy of Sciences, his scientific credentials are impeccable, but he also enjoys and does a superlative job as a teacher, not only at the graduate level, but also with non-credit courses such as this one. He is one of the world's authorities on ferns and is well acquainted with the Station and northern Michigan region by virtue of having been on the UMBS faculty and having led scores of field trips to the Station and the region.

Professor Wagner says about his course, "The major emphasis of this course will be on field trips to different habitats in the lower and upper peninsulas. We will study club mosses, spike mosses, horse tails and scouring rushes, as well as many general ferns. A real effort will be made to find the elusive and rare grape ferns and moon worts."

Aquatic Biology—Rex Lowe

Rex has been teaching Freshwater Phycology at UMBS for 14 summers and a Limnology course at Bowling Green State University. He is a highly skilled, popular teacher who has an uncanny ability to make all aspects of aquatic biology fascinating to his students. He very much enjoys teaching mini-courses and says, "We will explore life in an array of freshwater habitats in the northern Michigan region—exploring springs, small streams, rivers, bogs, fens, marshes and similar delights, plus large lakes and the Great Lakes."

Birds of Northern Michigan—Tom Van't Hof

This will be the fifth time that Tom has taught the Bird mini-course. Each year the class has been full and each year Tom has received unanimous rave reviews from the students. Northern Michigan is disproportionately rich in bird life in June, and Tom takes the class to dozens of important sites. Each of the five days will have a morning field trip (with the traditional bird class breakfast) including extended trips to the Upper Peninsula for boreal species and to see the rare Kirtland Warblers near Mio.

Tom has spent all or long portions of the last 10 summers studying birds at the Station. His dedication to this course and competence in the field are well known at the Station.

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**ABOVEGROUND BIOMASS AND PRODUCTION
FROM 1938 TO 1984 FOR FOUR ASPEN PLOTS
IN NORTHERN LOWER MICHIGAN**

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Ames, IA 50011

George M. Briggs¹ and David M. Gates²

University of Michigan Biological Station
Ann Arbor, MI 48109-1048

The University of Michigan Biological Station has several permanent study plots established in 1938 on which growth of individual trees has been monitored. These permanent plots provide a rare opportunity for determining changes in biomass and species composition during successional forest regrowth after cutting and burning, in that a true temporal sequence of samples on a single site is available. Such temporal sequences spanning more than one or two decades are extremely uncommon (Peet 1981). As a result, most studies of successional forest regrowth have necessarily assumed that a spatial array of different-age stands studied at one point in time represents the temporal sequence occurring on any one site, even though the validity of that assumption is not known.

Our primary objective here was to provide data on forest stand biomass and production that could be used to test hypotheses concerning forest growth after disturbance; the data also revealed successional trends in species importances on the plots. Our calculations of standing crop and production, via use of allometric equations, included the effects of mortality and recruitment on the plots. In contrast, most other studies of biomass and production have either neglected the turnover of stems or had to estimate turnover rates, thus introducing more uncertainty into the calculation. We demonstrate that the effects of uncertainty in time of mortality and recruitment of stems between sample dates are small.

HISTORICAL BACKGROUND AND FIELD SITES

The field sites are located at the University of Michigan Biological Station near Pellston, Michigan, U.S.A. (45°33'N, 84°42'W). Soil parent

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²Present address: Department of Biology, University of Michigan, Ann Arbor, MI 48109-1048

materials of this region are primarily of glacial origin. Soil texture is particularly variable, a characteristic that has had substantial impact on the vegetation occupying individual sites. Heavier-textured soils, mostly loams, derived from glacial till supported pre-settlement forests dominated by northern hardwoods (Gates 1930). Sandy soils derived from glacial outwash plains supported pre-settlement forests dominated by red pine (*Pinus resinosa*), eastern white pine (*P. strobus*), and eastern hemlock (*Tsuga canadensis*) (Gates 1930, Kilburn 1960a,b). Nomenclature follows Barnes and Wagner (1981). During the late 19th and early 20th centuries the entire area was logged. Regrowth after logging was hampered by frequent fires early in the 20th century (Kilburn 1960b). The combination of logging and fires drastically altered the composition and size of the forests in the area. Hemlock all but disappeared, and both pine species were reduced in importance. Bigtooth aspen (*Populus grandidentata*) and trembling aspen (*P. tremuloides*) became dominant species in much of the region (Kilburn 1960b). Many of the areas with heavier-textured soils have remained in agricultural use.

In 1938, F. C. Gates and W. F. Ramsdell set up seven 0.1 acre (0.04 hectare) plots that exhibited the range of forest and soil types found in or near the Biological Station, with the intention that forest development on the plots be traced for at least 50 years. One of the seven plots was logged soon after establishment and was not studied thereafter. Two plots on organic wetland soils are discussed in Sakai and Sulak (1985). The four plots dominated by aspen are analyzed here. Successional history of the plots was discussed by Roberts and Richardson (1985). Wells (1978) and Sakai et al. (1985) studied changes in stand composition in another plot comparable to our plot 4. Detailed descriptions of the sites are given by Roberts and Richardson (1985); we give brief summaries below.

Plot 2 is on a well-drained, flat area of sandy glacial outwash. The soil is a sandy, mixed, frigid, Entic Haplorthod (unpublished U.S.D.A.-S.C.S. map, 1976; Grayling, Michigan). Plot 3 occurs on a "sandy, somewhat stoney, glacial moraine with a small slope to the northwest" (Sylvester 1939, unpublished University of Michigan Biological Station student paper). The soil is a sandy, mixed, frigid, Alfic Haplorthod. Plot 4 has a mixed, frigid, Alfic Haplorthod soil with a surface layer of sand underlain by a layer of sandy clay at a depth of one meter; the site has a 10% slope to the northeast. The presence of clay improves both the water and nutrient retention properties of the soil (Hannah & Zahner 1970, Adams & Boyle 1982) and is reflected in better tree growth. Plot 5 is located in a flat area with sandy soils only one to two m above the water table of Douglas Lake. The soil is a sandy, mixed, frigid, Ortstein aerice Haplaquod.

As judged from increment cores, the oldest trees on Plot 2 appeared about 1909, presumably following one of the fires that swept the region. The oldest trees on Plots 3, 4, and 5 date from about 1919. It is unknown whether the oldest trees are of sprout or seedling origin.

METHODS

Each tree ≥ 1.0 m tall on a plot was identified, mapped, and its DBH (diameter at breast height, 1.4 m above ground) measured in the years 1938, 1945, 1951, 1955, 1968, 1973, and 1979. Plot 5 was not studied in 1968. This procedure produced data on the histories of individual stems, thus allowing determination of mortality and recruitment. In 1984, trees on all four plots were identified by species and measured but not mapped, so that the histories of individual stems between 1979 and 1984 were not known.

On each of the plots, estimates were made of aboveground standing crop (hereafter referred to as standing crop) and aboveground production (hereafter referred to as production) by use of allometric equations based on tree DBH. For each of the plots, we estimated standing crop from 1938 to 1984 using the equations of Cooper (1981), which were based on samples from the Biological Station, except for white pine and red pine. Cooper combined data for large white pine from North Carolina and large red pine from Minnesota with data for smaller trees from the Biological Station, to produce equations for those two species. Cooper developed equations for prediction of standing crop of leaves, live branches, dead branches, and boles for ten species, including all of the dominant trees in the area and most of the subdominant species, except sugar maple (*Acer saccharum*). Here, equations for red maple (*A. rubrum*) were used for sugar maple, which was a minor component of the forests. Equations for shadbush (*Amelanchier* sp.) were used for several understory species that Cooper did not study. We used our own equations (Briggs et al., in preparation) for aspen stems less than 5 cm diameter and Cooper's equations for larger aspens. The degree of error involved in applying these equations to stands of different ages is unknown. Cooper's equations are based on trees from sites of poor quality, similar to our plots 2, 3, and 5. We used the same equations for all our sites, even though Koerper and Richardson (1980) used different equations for aspen on poor versus moderate and good sites at the Biological Station, because Cooper's equations were based on a broader range of stand ages. Koerper and Richardson's (1980) results suggest that our values for standing crop and production for aspen on the good site (Plot 4) may be underestimates.

For each of the sample years, we used existing records of DBH for each individual tree. Stem diameter was interpolated for years between the sample dates using the assumption that the rate of diameter growth was constant over the sample interval, i.e., the average rate of diameter growth for an interval was calculated from the total diameter increment divided by the total time a tree was alive in an interval. For trees dying in an interval, we assumed no diameter growth occurred between the preceding sample date and the year of death; we assumed trees appearing (i.e., that became taller than 1.0 m and were first counted) in an interval grew a maximum of 1 cm in diameter per year. Since trees were not mapped in 1984 (so that individual stems from previous samples were not distinguished), DBH was not estimated for the years 1980–1983.

We determined upper and lower limits for standing crop and production for dates between the sample years by making different assumptions about when trees died or appeared. A lower limit was produced by assuming that all trees dying in the interval between two sample years died in the first year following the first sample date and all trees appearing in the interval appeared at the end of the interval. An upper limit was produced by assuming that all trees dying in the interval died immediately before the end of the interval and all trees appearing in the interval appeared at the start of the interval.

Production on each plot was calculated for each year from 1939 through 1979. Production of bole material, live branches, and dead branches was calculated from the difference in standing crop values of each tree on successive years. Leaf and small twig production for each living tree on the plot was taken to be the standing crop biomass of leaves and small twigs estimated as described above, except for evergreen species, where leaf production was assumed to be 0.3 of the standing crop (Cooper 1981).

Data on recruitment, mortality, and density of stems on the plots are given by Roberts and Richardson (1985). Our calculations are based on the same historical records used by them and so can be related directly to their results. Briefly, aspen is being replaced in the canopy by red pine, white pine, red maple, and red oak, with sugar maple and beech increasing in abundance

TABLE 1: Total stem densities (#/ha), by size class (cm), for the plots.

Year	0-1	2-6	7-11	12-16	17-21	22-26	27-up
Plot 2							
1938	890	1483	815	173	0	0	0
1945	445	1235	618	420	0	0	0
1951	692	1384	642	445	124	0	0
1955	766	1137	544	420	222	0	0
1968	346	964	346	469	247	124	0
1973	74	1063	395	371	272	198	25
1979	173	815	346	297	346	198	25
Plot 3							
1938	2001	3533	198	99	74	0	0
1945	2150	2767	371	99	49	49	0
1951	1927	1878	791	99	74	25	49
1955	1581	1334	939	222	49	49	49
1968	1606	1384	642	420	74	49	99
1973	766	1656	568	469	124	49	99
1979	2767	1408	593	321	272	0	148
Plot 4							
1938	3385	6350	1186	148	25	0	0
1945	914	4472	1829	494	25	0	0
1951	395	2718	1013	791	272	25	0
1955	469	1754	865	642	371	49	25
1968	2718	939	840	272	494	247	99
1973	2545	2174	815	198	445	297	148
1979	3039	1532	741	99	321	198	247
Plot 5							
1938	1310	1334	1161	124	0	25	0
1945	3385	642	321	99	0	0	0
1951	1680	1137	297	74	49	0	0
1955	1557	717	346	74	25	25	0
1973	198	791	297	49	197	25	25
1979	618	568	247	49	173	74	0

in the understory. These trends in species replacements are also indicated in Table 2. Patterns of recruitment and mortality will not be addressed further here.

RESULTS

Total stem densities in the smaller size classes generally decreased from 1938 to 1979, while density in larger size classes increased (Table 1). The increase in number of larger stems led to an increase in total aboveground standing crop of trees on each of the plots over the period 1938-1984 (Fig. 1). In 1938, the standing crop ranged from 1.8 kg/m² on plot 3 to 3.7 kg/m² on plot 4, which had the highest-fertility soil. Although the forest on plot 2 was about 29 years old in 1938, as compared to 19 years for forests on the other three plots, plot 2 had the second lowest total standing crop in 1938. Standing crop on plot 5 decreased precipitously from 1938 to 1945 (see

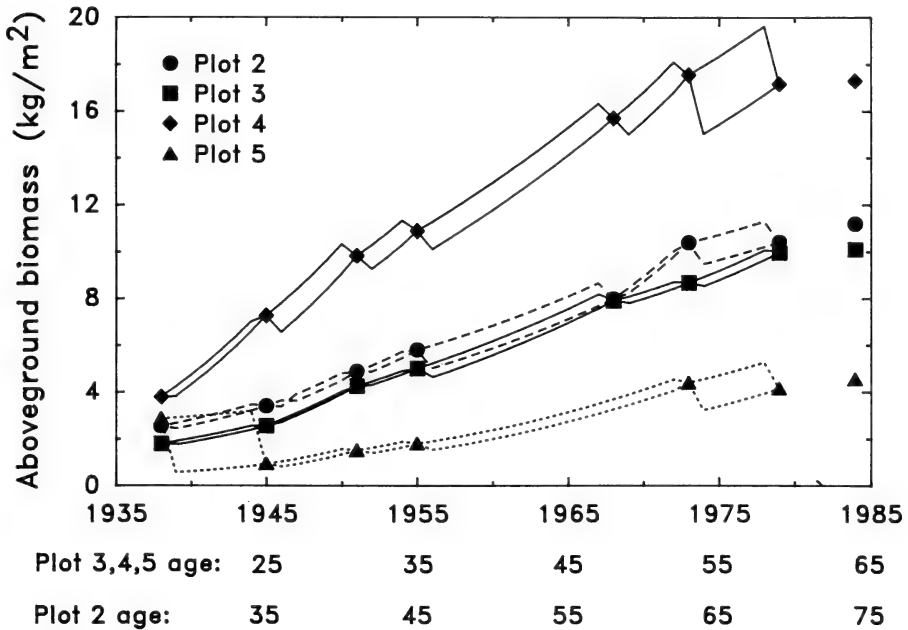


Figure 1. Total standing crop (aboveground dry biomass) on the plots from 1938 to 1984. The lines show the effects of using different assumptions about timing of mortality and recruitment between sample years. Trees were measured but not mapped in 1984, so biomass could not be estimated for 1980–1983. KEY: ●Plot 2, ■Plot 3, ◆Plot 4, ▲Plot 5.

results for species, below), but then increased until 1973, reaching a value about five times the biomass in 1945. The other plots had fairly steady increases in standing crop from 1938 until 1973; all three reached values about five times their biomass in 1938. Since 1973, biomass on all four plots has been nearly constant. The small size of the plots makes conclusions difficult to draw, since the death of a single large tree can noticeably affect stand biomass, but the similarity among plots suggests that the plots have indeed reached a real plateau in biomass.

The different lines for each plot in Fig. 1 show the effect of different assumptions about the time of mortality and recruitment in each sample interval; the lines delimit upper and lower limits for biomass in each interval. The greatest uncertainty in biomass (i.e., the greatest difference between the upper and lower limits) occurred in plot 5 during the period 1939–1944 and in plots 2, 4, and 5 during the period 1974–1978; these were periods of higher mortality in the plots.

Since the approximate date of origin for the forest on each plot is known, the curves in Fig. 1 could be extrapolated back to zero, assuming that all the forests appeared after fires had more or less completely removed

vegetation on the sites. The greatest uncertainty in such extrapolation is in how fast each site was recolonized; depending on whether the new forests developed primarily from sprouts from extant root systems or from seeds, there could be considerable differences in the initial rate of biomass accumulation on each site. Clumping of maple and aspen stems on the plots suggests that most stems are probably of sprout origin, although patchiness of microenvironments and seedbeds after fire conceivably could have produced similar clumps of stems from seeds.

Bigtooth aspen was the dominant species, in terms of biomass, in 1938 on all plots except plot 5; it became the dominant species on plot 5 in the 1940s (Table 2). Bigtooth aspen has since maintained its dominance on all sites, with steady increases in biomass until the 1970s, although from 1955 to 1984 its percentage of the total biomass declined on plots 2, 3, and 4. Since 1938, there have been gradual increases in biomass of red pine, white pine, red oak, and red maple due both to growth of existing trees and to recruitment of additional stems (Table 2). The only major species with net declines in both absolute and percentage biomass from 1938 to 1984 were paper birch on plot 2 and trembling aspen on plot 5, although white pine on plot 3 experienced a small decrease in its percentage of the total biomass (Table 2). Only on plot 5 did dominance shift among species, from trembling aspen to bigtooth aspen. Trembling aspen had the greatest standing crop on plot 5 in 1938, but declined drastically by 1945. Sylvester (1939, unpublished University of Michigan Biological Station student paper) noted an insect infestation in 1939 that was killing trembling aspen but not bigtooth aspen on plot 5. However, the plot data also show declines in bigtooth aspen and paper birch between 1938 and 1945, perhaps due to a storm in 1940 (Sakai & Sulak 1985). Since 1945, trembling aspen has maintained a fairly constant total standing crop, while bigtooth aspen, paper birch, and red maple have increased their standing crops.

One example of the distribution of biomass among plant parts, for plot 4, is shown in Table 3. Boles (trunks) always accounted for the greatest fraction of the total standing crop, and the fraction increased from 1938 to the 1970s. Total bole biomass in 1979 was five times that in 1938. Live branches were the second largest component of the total standing crop; branch biomass in 1979 was 1.7 times that in 1938, although branches as a fraction of total standing crop decreased over time. The biomass of leaves increased by only 40% from 1938 to 1979, while biomass of dead branches increased only by a factor of 2, so that their relative fractions of total standing crop decreased. The small increase in leaf biomass resulted from a nearly constant aspen leaf biomass and small increases in leaf biomass of other species. Thus, the aspen-dominated canopy on this site apparently was nearly fully developed within a few years after the origin of the forest; due to the shade intolerance of aspen, once a maximum density and depth of the canopy was reached, no more aspen leaves could be supported regardless of the size of the boles. Additional leaves thus have been produced only by more shade-tolerant species. On the other plots, leaf biomass has also been relatively constant (data not shown), but at levels below that

TABLE 2: Aboveground biomass of each species on the plots, as a percentage of the total aboveground standing crop on a plot. Values are given for three sample years, to illustrate the general pattern seen over the entire sequence of sample years.

Species	Year	Plot 2	Plot 3	Plot 4	Plot 5
Bigtooth aspen	1938	79.0	39.3	85.4	10.9
	1955	76.4	48.6	86.2	29.3
	1984	61.9	43.2	82.3	44.1
Trembling aspen	1938	0.7	0	0.2	65.2
	1955	0.7	0	0	16.5
	1984	0	0	0	8.3
Red maple	1938	4.3	3.6	8.3	0.01
	1955	4.9	4.1	10.5	6.2
	1984	7.8	6.5	12.1	18.9
Red oak	1938	10.1	2.2	0	0
	1955	12.0	2.5	0	0
	1984	15.9	5.7	0	0
Paper birch	1938	1.8	5.4	0	22.5
	1955	2.3	2.7	0	43.7
	1984	0.3	3.1	0	25.4
Red pine	1938	0.7	38.4	0	0
	1955	2.2	33.7	0	0
	1984	9.9	31.8	0	0
White pine	1938	0.2	11.1	0	0
	1955	1.0	8.5	0	0
	1984	3.8	8.9	0	0.5
Sugar maple	1938	0	0	0.6	0
	1955	0	0	1.4	0
	1984	0	0	2.3	0
Beech	1938	0.03	0	0.1	0
	1955	0.1	0	0.7	0
	1984	0.02	0	1.2	0
Miscellaneous	1938	3.3	0.03	5.5	1.4
	1955	0.6	0.1	1.2	4.3
	1984	0.24	0.9	2.2	2.9

on plot 4; leaf biomass on these plots is possibly limited by nutrients rather than light.

Total yearly production generally increased from 1939 to 1979 on plots 2, 3, and 5, whereas production on plot 4 did not show such a long-term trend (Table 4). Production on plots 2 and 4 was highest in 1969–1973. It is not clear whether these peaks were temporary deviations from long-term patterns of gradual increase in production or whether there has been a real change in the trend since 1973. A decline in production on older sites is predicted by the regressions of site age versus production developed by Cooper (1981) for similar sites, but peak levels of production were several times higher than those predicted by Cooper's equations and the two plots are of different ages. In contrast, plot 3 has exhibited no drop in production levels since 1973 even though it has a composition and standing crop similar to plot 2 (Table 4). Plot 5 had by far the lowest yearly production, whereas

TABLE 3: Biomass of plant parts on plot 4 for the sample years. Mass values are kg/m². Percent values are percentage of total biomass in that year.

Year	Leaves		Live Branches		Dead Branches		Boles	
	mass	%	mass	%	mass	%	mass	%
1938	0.237	6.3	0.499	13.2	0.109	2.9	2.945	77.7
1945	0.307	4.2	0.792	10.9	0.145	2.0	5.435	74.8
1951	0.311	3.2	0.937	9.6	0.150	1.5	8.415	85.7
1955	0.305	2.8	0.976	9.0	0.153	1.4	9.442	86.8
1968	0.350	2.2	1.274	8.1	0.199	1.3	13.883	88.4
1973	0.371	2.1	1.418	8.1	0.222	1.3	15.553	88.6
1979	0.330	1.9	1.330	7.8	0.219	1.3	15.273	89.1

production on plot 4 was much higher than on any of the other sites (Table 4). The production on plot 4 for the years 1974–1979 ($762 \text{ g m}^{-2} \text{ yr}^{-1}$) compares favorably with that ($617 \text{ g m}^{-2} \text{ yr}^{-1}$) calculated by us for a plot established by Wells (1978), which is similar in site quality and forest age to plot 4. The Wells plot is roughly 25 times larger and should yield a more reliable estimate.

The two different assumptions about patterns of mortality and recruitment resulted in average production values for each interval that typically differed from the mean of the two values by less than 3%. Only in plot 5 in the 1939–1945 interval was there a large (30%) difference from the mean.

One example of yearly production by plant part, for plot 4, is shown in Table 5. Production of boles (trunk wood and bark) was roughly double the production of leaves, whereas production of branches was much lower. Production of each plant part as a percentage of total production was relatively constant over time (Table 5).

DISCUSSION

The reliability of estimates of standing crop and production produced via use of allometric equations necessarily depends heavily on the reliability of the equations used. Except for large red pine and white pine, our equations were derived from trees at the Biological Station, which decreases the errors that occur when equations derived from one site are applied to stands at another location. However, it is unknown how much error is involved in applying a set of equations derived over a relatively short period in the life of a stand to the development of the stand over time, i.e., how much the allometric relationship changes over time with changes in tree age, size, and density. A third limitation in using allometric equations typically occurs when rates of mortality and recruitment must be estimated. Here, overall rates of mortality and recruitment were known because individual stems were tracked; only the timing of mortality and recruitment between sample years was unknown. However, uncertainty in the date of appearance and

TABLE 4: Mean total yearly production on each plot for the intervals between sample years. Values are the average, over all years in the interval, of the calculated maximum and minimum values for each year, where maximum and minimum values were derived from different hypothetical patterns of mortality and recruitment. Units are $\text{g m}^{-2} \text{yr}^{-1}$.

Years	Plot 2	Plot 3	Plot 4	Plot 5
1939-45	285	307	807	131
1946-51	453	528	919	181
1952-55	491	497	815	183
1956-68	483	593	780	245*
1969-73	836	593	970	245*
1974-79	534	692	762	284

*mean for 1956-1973

date of death for stems appearing and disappearing between sample dates had relatively little effect on calculated standing crop and production for most of the study period, as demonstrated by the limits established by choosing extreme values. Early in the study, only plot 5, with considerable mortality between 1938 and 1945, exhibited a wide range of potential values between the sample years. Variation in the other plots was low because of low recruitment and low mortality of larger stems in these relatively young, aspen-dominated stands. Not until the 1970s, when some older, larger stems died, did plots 2, 4, and 5 also have the potential for much variability. Even so, such variation in estimation of both standing crop and production is necessarily less than that which occurs when overall rates of recruitment and mortality must be estimated, as is the case when individual stems are not tracked over time. For example, if mortality is not accounted for at all, estimates of production based solely on successive estimates of standing crop may be substantially lower than the "true" production. This occurs because the production estimate is low by a value equal to the standing crop of trees that died during the interval; any production by such trees before they died also will be missed.

Aspen is widely recognized to be a short-lived tree, often reaching ages of only 50 to 80 years, although some stems live well beyond 80 years (Fowells 1965). Thus, in the 1970s and 1980s, many of the original aspen stems on the plots have neared the end of their expected lifespans. Even so, no widescale death of aspen has yet occurred; several large trees died in the 1973-1979 interval, but there was little or no mortality between 1979 and 1984 (as estimated from comparisons of diameter distributions in 1979 and 1984). Sakai et al. (1985) studied a plot established in 1974 by Wells (1978) on a site close to and similar in quality to our plot 4 and also found very little mortality over the years 1974 to 1981. Aspen typically lives longer on sites of better quality (Kittredge 1938); one would therefore expect plot 4 to be the last plot to show deterioration of aspen.

Low or zero recruitment of aspen stems on the plots (Roberts & Richardson 1985) suggests that the composition of the forests will change

TABLE 5: Mean total yearly production of plant parts on plot 4 for intervals between sample years. Values are the average, over all years in the interval, of the calculated maximum and minimum values for each year, where maximum and minimum values were derived from different hypothetical patterns of mortality and recruitment. Mass values are $\text{g m}^{-2} \text{ yr}^{-1}$. Percent values are percentage of total production in that year.

Years	Leaves		Live Branches		Dead Branches		Boles	
	mass	%	mass	%	mass	%	mass	%
1939-45	267	33.1	51.7	6.4	7.9	1.0	481	59.6
1946-51	271	32.7	51.4	5.6	6.8	0.7	560	60.9
1952-55	288	37.2	39.5	4.9	6.0	0.7	467	57.3
1956-68	305	41.8	32.7	4.2	5.2	0.7	416	53.4
1969-73	360	37.1	48.5	5.0	7.5	0.8	554	57.1
1974-79	347	45.5	24.4	3.2	4.7	0.6	412	54.1

considerably in the future. Although new aspen sprouts could appear after the old aspens die and create openings in the canopy, it seems more likely that the existing hardwood and pine stems will fill in the gaps. Thus, forests of pines, maples, and red oak will probably replace the present aspen-dominated stands, although clearcutting or other large-scale disturbances could promote regeneration of aspen.

Aboveground standing crop for temperate deciduous forests of the Great Lakes region has been estimated to range from 6 to 60 kg/m^2 (Crow 1978). Our plots are at the lower end of this range, but have standing crops similar to other aspen-dominated forests in the region. Crow (1978) found a value of 9.2 kg/m^2 for an aspen forest in northern Wisconsin, similar to plots 2 and 3. Bray and Dudkiewicz (1963) and Pastor and Bockheim (1981) found values of 20.7 and 19.7 kg/m^2 , respectively, similar to plot 4. Relatively cool temperatures and a short growing season at the northern edge of the temperate forest zone plus sandy soils low in nutrients and water-holding capacity are likely major contributors to the low standing crops at the Biological Station. Differences between the plots strongly suggest that soil fertility is a major limitation on growth on many sites; soil fertility was the major environmental difference between plot 4 and the other plots (Roberts & Richardson 1985). Moreover, the Biological Station forests presently are dominated by an early successional species and have not reached a stable state. With time, successional processes may produce a forest with more biomass on these sites, as bigtooth aspen is replaced by longer-lived, heavier-wooded hardwood and pine species. However, there may also occur a countering decrease in biomass due to a change from an even-aged aspen forest to an uneven-aged, mixed forest with gaps due to mortality.

Total net production in temperate forests has been estimated at 0.6 to 3 $\text{kg m}^{-2} \text{ yr}^{-1}$ (Westlake 1963). Our estimates for aboveground production are compatible with these and indicate that our stands are at the low end of the range for temperate forests as a whole. Certainly, cool temperatures and

sandy soils again contribute to these relatively low values. Stand age is probably not a major factor; Cooper (1981) predicted peak production in aspen stands at around 45 years. Our stands had maximum production values in the 1970s, at stand ages of 50–70 years. The relatively constant, higher production on plot 4 apparently is due to the denser, more uniform stand on that more fertile site. However, we cannot discount the possibility that some of the variation among plots is due to genetic differences among aspen clones or even partly due to errors in applying one set of allometric equations to trees on sites of different fertility. On plots 2, 3 and 5, production has increased with time, presumably as the canopies filled in the original gaps in the lower-density, patchy stands on these lower-fertility sites. Even so, production on these three plots may now be leveling off, as the older aspen stems near the ends of their expected lifespans.

SUMMARY

Aboveground biomass and production were calculated for forest stands on four 0.1 acre (0.04 ha) permanent plots in northern lower Michigan, U.S.A., on which individual trees were measured at 4–13 year intervals from 1938 to 1984. Stands were 19–29 years old in 1938. Bigtooth aspen (*Populus grandidentata* Michx.) was the dominant species, in terms of biomass, on three of the plots for the entire period; it was the dominant species on the fourth plot after 1960. Standing crop biomass increased five-fold from 1938 to 1984 on three of the plots; biomass on the fourth plot declined until 1945 due to mortality of stems from unknown causes but then also increased five-fold by 1984. The rate of increase in standing crop has slowed since 1973. In 1984, standing crop was 17.5 kg/m^2 on a higher-fertility site and ranged from 4.8 to 11.2 kg/m^2 on the three lower-fertility sites. Total yearly production doubled from 1938 to 1979 on the three lower-fertility sites, reaching values of 284 to $692 \text{ g m}^{-2} \text{ yr}^{-1}$ in 1979. Production on the higher-fertility site varied from 780 to $970 \text{ g m}^{-2} \text{ yr}^{-1}$, with no significant trend when viewed over the entire period. Uncertainty as to time of appearance or death of stems between sample dates was demonstrated to have relatively little effect on calculated standing crop and production.

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We thank Robert Vande Kopple and Martha Samson for assistance with the plot data. We thank all those persons, many of them unknown to us, who participated in measuring the plots over the half-century since their establishment. Supported by the United States Department of Energy under contract DE-ACO2-79EV10091.

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REVIEW

A GUIDE TO ENJOYING WILDFLOWERS. By Donald and Lillian Stokes. Illustrated by Deborah Prince and the authors. Little, Brown and Co., Boston. 1984. 352 pp. \$18.45 hard-bound, \$10.95 paper.

Here's another in the Stokes series of nature guides, this one devoted not to *all* wildflowers in North America but 50 of the 'best loved', most being common to woods, fields, and water's edges of urban and rural areas across the United States. Now the neat part about such a small selection . . . it enables the authors to discuss the *whole* life cycle of each plant, thus proving an excellent book for amateur botanists, too many of whom (including me) have the bad habit of flitting quickly from one flower to the next like a butterfly—without really observing closely.

In this guide each plant rates five sections: Introduction, Wild and Garden Relatives; What You Can Observe; Flower-Watching (in minute detail); and Through the Seasons. The latter enables the reader to go out and plant-watch at almost any season.

After reading the section on one of my favorites, the Jack-in-the-Pulpit, I made the big discovery that plants can change sex from one season to the next and do this about 50 per cent of the time! (The rest of you probably already know this.) So starting this spring, I'm planning to stake out and watch a patch of these Jacks for a few years to see if this really is the case. Thanks to the guide, a fun book for amateurs like me, I can now tell the male from the female flowers.

Fifty color paintings and hundreds of line drawings serve as lovely visual aids.

— June Hicks
(former Garden Editor, *The Detroit News*)

Correction: The author, Gerald F. Guala II, of the paper, "*Poa bulbosa* L. (Poaceae) in Michigan", was omitted from the "CONTENTS" of the previous issue. We regret the omission.

The January issue (Vol. 27, no. 1) was mailed on February 13, 1988.

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On the cover: *A view of the Schjolin Plant Conservation Garden.*
Photo by J. R. Wells, 1987.

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THE

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**FREDERICK J. HERMANN (1906-1987):
THE EVOLUTION OF A BOTANICAL CAREER**

Edward G. Voss and A. A. Reznicek

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Ann Arbor, MI 48109

Late in June of 1922, a 16-year-old student who had just completed his sophomore year in high school at Laurium, in the "Copper Country" of Michigan's Upper Peninsula, addressed a letter to "The Professor of Botony [sic], University of Michigan." This letter fell into the hands of Professor Harley Harris Bartlett, shortly to become chairman of the Department of Botany as well as director (since 1919) of the Botanical Gardens. Professor Bartlett was so impressed with the color forms of the coral-root orchid from Copper Harbor that young Fred Hermann sent (in a separate box) that he published on them immediately, in the August number of *Rhodora*, quoting almost all of the letter pertaining to them.

In October, 1922, Fred Hermann wrote again to Mr. Bartlett, thanking him for extra copies of the *Rhodora* number, consenting to ship some specimens of wild roses, and mentioning that he had just started a herbarium that summer, which had "only forty specimens" thus far. He added a postscript that he hoped "to attend your University when I finish High School. Could you tell me if it would be necessary for me to take more than two years of Latin to meet the entrance requirements?" By the time he left the University of Michigan in 1938, he had made nearly 10,000 collections (plus duplicate sheets), over half of them in Michigan.

Frederick Joseph Hermann was born in Laurium (near Calumet, in northern Houghton County) April 14, 1906. He spent his summers as a boy at Copper Harbor (Keweenaw County) with his great-aunt, who then owned a great portion of that area. What first aroused his interest in botany we do not know, but his mother, Olive Wilkins Hermann, was interested in botany and very likely passed that interest on. In Hermann's herbarium was one collection made the year before the 40 gathered in 1922. That is a sheet of the dragon's mouth orchid, *Arethusa bulbosa*, surely one of our handsomest wildflowers (and one whose conservation was of special concern to Fred till the end of his life). Perhaps the sight of this species helped to inspire him to begin collecting. In his early years at the University, he vacillated between botany and classical languages—always with excellent academic performance, resulting in election to four honorary societies: Phi Beta Kappa (scholarship), Sigma Xi (scientific research), Phi Kappa Phi (scholarship), and Eta Sigma Phi (classics).

He received his A. B. degree in 1928 (magna cum laude) and his M. A. in 1931 in Greek and Latin. The summer of 1928 he spent at the University of Michigan Biological Station on Douglas Lake, where he took ornithology and bryology. Writing enthusiastically to Professor Bartlett, he

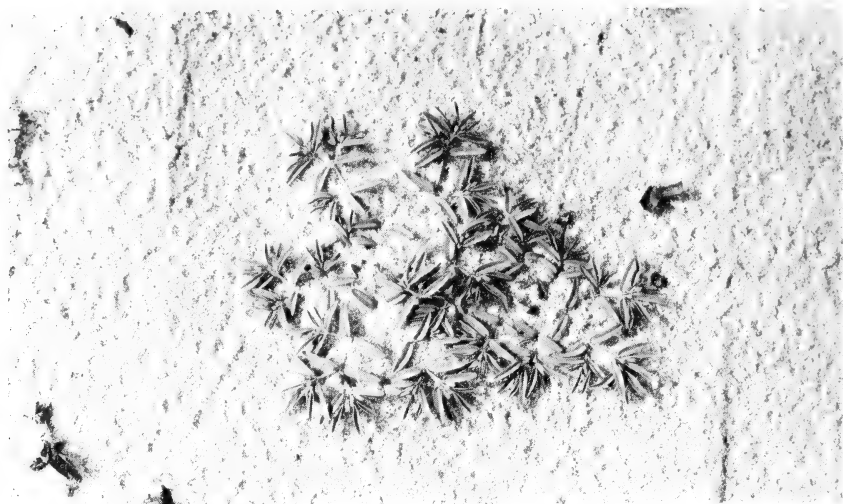


Figure 1. Seaside Spurge (*Euphorbia polygonifolia*), a species found only on sandy shores of the Great Lakes and the Atlantic, in a dune blowout north of Ludington, Michigan. Photo by F. J. Hermann, August 14, 1930.

reported: "I have been having great fun with mosses since I've been here. The bogs around camp and the limestone bluffs at Mackinac Island are a paradise for bryologists, and Dr. Nichols is an extremely interesting guide." During the summer of 1930, Hermann made a survey of the Lake Michigan dune flora, from the Straits of Mackinac southward, for Professor Irving D. Scott of the Department of Geology, University of Michigan, who had authored a classic volume on *Inland Lakes of Michigan* and was trying to learn which of the native plants were the most efficient sand-binders (see cover & Figs. 1 & 2). While Fred was working on his master's degree, Professor Bartlett arranged for him to have an assistantship in the Botanical Gardens even though at the time he was not planning a professional career in botany. He continued at the Gardens until 1931, when he spent three months of the summer as park naturalist at Lassen Volcanic National Park in California.

But then came an offer of an instructorship in the Biology Department at Temple University, so Fred and Dorothy (his wife since 1930) moved to Philadelphia for two years. He was taken under Bayard Long's wing at the Academy of Natural Sciences and also enjoyed field trips with F. W. Pennell. M. L. Fernald came down from Harvard to work at the Philadelphia Academy, and Hermann had his "long hoped-for introduction to him." Fernald and Long encouraged him to work on *Juncus* (as he was considering) for a Ph. D. problem. Falling enrollments at Temple and budget cuts during the Depression led Temple to cut its newer faculty, and after spending the summer of 1933 collecting in Wyoming and elsewhere in the West, Fred returned to Ann Arbor. Bartlett had offered an assistantship in the



Figure 2. "Ghost forest" of formerly buried trees on bare dunes at Silver Lake, Oceana County, Michigan. Photo by F. J. Hermann, August 19, 1930.

Botanical Gardens again, as well as free occupancy of the house at the Gardens (the old Packard Road site) in consideration of services as custodian of the property nights and holidays. He soon added a teaching assistantship in botany (to help Professor John H. Ehlers) and received the title of curator at the Gardens—where he had dozens of species of *Carex* in cultivation.

While yet technically a graduate student, Fred Hermann was building a fine professional reputation. During the 1935-1936 academic year he declined an instructorship at the University of Oklahoma, where he would doubtless have enjoyed being with George J. Goodman, with whom he had collected for a week or more in Wyoming in 1933 and for whom he had a high regard. Professor Bartlett noted wryly in 1936: "When I visited the California Academy of Sciences on my way to the Philippines I announced myself as from Michigan. The Curator to whom I spoke said: 'Oh yes, the Botanist there is Mr. Hermann. They are lucky to have him. Who else is there in botany at Michigan?'" His treatment of *Juncus* in Kansas was published in 1935, and *Carex* for the same state followed the next year, both based on specimens made available by Frank C. Gates. Kenneth K. Mackenzie, long the leading authority on *Carex* in North America, died in October of 1934, and as Hermann wrote in a 1937 letter, "Since Mackenzie's death no one else seems willing to undertake *Carex* so that I seem to have the job of determining *Carices* for the whole country and taking care of these thousands of collections is in itself a man-sized job." The die was cast. Treatments of *Carex* (and also often *Juncus*) started by Hermann in Ann Arbor were to follow for Nevada (1940), Indiana (1940), and Michigan

(1941). This pesky sedge genus, topping all other vascular plant genera in North America, with over 500 species, was in competent hands!

Fred was under some pressure not only to identify sedges and rushes, but also to finish his degree and move on—a phenomenon not entirely unknown to graduate students today. Three days before Christmas, 1937, he wrote to Clarence Hanes, “Have just finished and fired in my darned thesis today”; and on February 3, 1938, after a long report on identifications, he added, “Have just weathered the last step in the Ph. D. ordeal—the final half-day oral examination. It’s a relief to have it all over with but somehow I am not aware of any pronounced metamorphosis.” Like “Plain ol’ Charlie Deam” in Indiana, Fred Hermann was not puffed up over academic formalities, and he wrote to Hanes in March: “If you don’t mind I would rather not have you ‘Doctor’ me. I had hoped to be able to go to my grave without having to bear the stigma of a Ph. D. and I put off the thing as long as I possibly could but when the University insisted upon it as a prerequisite to any advancement at all I had to give in. Still it would be nice to keep it in the dark as much as possible.”

The Ph. D. thesis, done nominally under Professor Bartlett’s direction, was titled “The Genus *Carex* in Indiana.” Its 117 typewritten pages and 139 maps included essentially the same text as contributed to Deam’s *Flora of Indiana*, plus ecological and phytogeographical analysis. In his introduction, Hermann noted that he had made four collecting trips with Deam in Indiana, visiting most counties, during the previous three years. To Deam’s great flora (1236 large printed pages) he contributed more than merely the treatments of *Carex* and Juncaceae. He also read both the entire manuscript and the proof for Deam, who acknowledged that he was “exceedingly helpful in many ways.” A deadline of November 1, 1937, was the goal for Deam’s flora to go to press (actually transgressed by some 11 months), and no sooner had Fred finished his manuscript for that, than he began “to scrape together material for an account of *Carex* in Michigan,” as he wrote to Hanes at the end of October 1937. He had hoped in this to cite every specimen he had seen, or at least to map every locality; but ultimately he had to settle for maps too small even to show the herbaria from which specimens had been seen from each county (as Deam had used). The Michigan *Carex* treatment was finally published at the beginning of 1941 (and supplemented a decade later).

At the same time that Fred Hermann was being so helpful to Deam, he was also, with characteristic generosity, being very helpful to Mr. and Mrs. Clarence R. Hanes of the village of Schoolcraft, in Kalamazoo County, Michigan. Dedicated and astute amateur botanists, the Haneses sent specimens to the University of Michigan for identification. Fred reported to them on many of these, discussed taxonomic and nomenclatural points, suggested specialists whose opinions should be sought, directed them to literature, and shared a great deal of advice—sometimes writing every few days. On February 3, 1937, for example, he tactfully wrote:

I hope you will not mind some criticism. When I first began exchanging duplicates of my early collections with other herbaria I had no comments from the curators of some of them, but from others came some pretty sharp criticism of my specimens some of which I resented at the time but now it is to the most unsparing of them that I feel most grateful. I have since then visited most of the larger herbaria in the country and studied their methods, and seen how often specimens they receive have found their way to the waste basket instead of to the mounting-room either for lack of adequate data or because the specimens were fragmentary or incomplete. The funds available for most herbaria are very limited and in many their filing-space for specimens must be carefully conserved so that they cannot afford to mount and preserve any but perfect specimens. In several, too, I have seen specimens, otherwise perfect, discarded because they had not been thoroughly cleaned; the plants could not be mounted and filed in the herbarium with their roots still caked with mud. . . . I think the value of your specimens would be immensely increased if they had more complete data: the exact locality . . . , the habitat and type of soil, the relative abundance if this is marked in the field, and the collector's collection number. . . . I have known monographers to discard specimens lacking labels because they did not have the time, or assistance, to write them out. I am enclosing labels . . . which may serve as samples. . . . In making specimens it is very essential to see that they are not longer than the herbarium sheet upon which they are to be mounted; to fold them carefully while they are fresh if the plants are longer than 16 1/2 inches Unless the plant is rare, the material ought to be ample to pretty well fill the mounting sheet. Well, a good deal of this you may already know but if not some of it may be of help to you.

Four letters later (March 11), he mentioned that he was distributing the 8000 sheets he collected in 1936 to 46 herbaria. (A 1936 trip to the Keweenaw Peninsula was sponsored by the New York Botanical Garden, which received the first set of specimens.) He also mentioned editing a manuscript by Mr. Hanes and efforts to get it typed for submission to the *Papers* of the Michigan Academy. Fred frequently saw to the editing, typing, and presentation of papers written by Hanes, and even contributed some of his own new records for the state to papers published solely under Hanes' authorship. He had labels set up and printed for him. Later colleagues and correspondents of Fred's will recognize this early and so characteristic kindness, helpfulness, and patience with those sincerely seeking help. Dedication to botany and to those who shared that dedication marked his life. March 15, 1937, he wrote to Hanes: "I can sympathize with you on the lack of financial return in botanical work. The building up of a taxonomic library and my collecting have been a great expense to me, particularly the several expeditions I have made, and every cent I can spare from living necessities goes into it. But it is a fascinating field and well worth it!"

Hermann apparently advised the Haneses on their estate planning as well, and in 1938 agreed to act as executor of their wills; after leaving Michigan later that year, he recommended Bartlett as he "is well disposed toward local floristic studies." Fred continued: "If your wills state that any money is to be used for taxonomic and/or distributional studies of the vascular flora of Michigan, and if I recall correctly this was about it, I should think that would be about foolproof." In 1955, barely more than a year before the death of Mr. Hanes, Fred wrote of his willingness to head a committee to carry out the terms of a will. So the roots of the Clarence R. and Florence N. Hanes Fund, established on the death of Mrs. Hanes in



Figure 3. F. J. Hermann collecting about 1933.



Figure 4. F. J. Hermann, May 1964.

1966, go far back. That Fund has made possible the publication of two volumes (thus far) of a *Michigan Flora* resulting from a project authorized at The University of Michigan less than two weeks—as it happened—following the death of Mr. Hanes. In several ways, Fred Hermann was champion of a state flora. In 1937 he wrote the Haneses of his hope “to stay here and start at a Michigan Flora in earnest” after completing his portion of Deam’s *Flora of Indiana*. And 14 years later, dispirited by the routines of Government employment, he admitted, “There was never much point in my specializing in botany anyway except to work on a Michigan Flora.”

He had done the next best thing possible under the circumstances, namely to help and encourage the Haneses in their excellent *Flora of Kalamazoo County*, published in 1947 but planned for over a decade. Hermann read an early draft of the manuscript, recommended type faces, and brought the nomenclature up to date as the book neared publication (privately, by the authors). Noting that O. A. Farwell had “been publishing notes on the Mich. flora promiscuously for years,” and that “it is a great puzzle to know whether a thing has been reported by Farwell or not” in papers “so execrably written and abominably edited that it is a Chinese puzzle to weed out from all the chaff what little good there is in them” Fred prepared a card index, by species, to all of Farwell’s published records [in nearly 50 papers pertaining to Michigan]. (In 1957, the Farwell index was generously sent for use—an immense help—in the present Michigan Flora project, for which Hermann examined thousands of specimens and a draft

manuscript of *Carex* at an especially busy time in his professional career.) As late as 1952, there was hope of obtaining funds to enable the University of Notre Dame to support Hermann in preparing a flora of Michigan.

Although Fred had hoped for "advancement" at Michigan upon completion of his Ph. D., no way opened, even upon the retirement of Dr. Ehlers in 1938. He first turned down a job offer from the Department of Agriculture, as it would mean giving up "any attempt at a Flora of Michigan and probably my interest in Juncaceae and *Carex*," but the offer was pressed again and he decided to accept it, joining the Bureau of Plant Industry as of July 1, 1938. He remained there until 1961, when he became curator and principal botanist of the U. S. Forest Service Herbarium. When that herbarium was moved to Fort Collins, Colorado, in 1970, the change in atmosphere was a welcome relief from the pace of life in the Washington, D. C., area, and Fred appreciated being again in the West, where he had enjoyed considerable field work in earlier years. (In August of 1929 he wrote Professor Bartlett: "Our two weeks in Glacier National Park and the week at Mount Rainier were paradise. I was never so wholeheartedly a botanist as I was during our sojourn in the alpine meadows of Rainier. I should not have believed it possible that such a variety of species could be concentrated in so small an area.") Over the years, he did considerable field work in the Rocky Mountains.

His research on legumes for the Division of Plant Exploration and Introduction, Bureau of Plant Industry (later, Agricultural Research Service) is a matter of record in his bibliography, including monographs of *Trifolium* (clover), *Arachis* (peanut), *Vicia* (vetch), and *Glycine* (soybean). He also worked extensively on the leguminous genus *Lonchocarpus* (barbasco, source of rotenone), and was responsible for monocot identifications. In 1943-1944, he was in Colombia, South America, like so many taxonomists during World War II seeking cinchona bark, the source of quinine, under the Office of Economic Warfare. Upon returning to Washington, he continued to devote much of his spare time to sedges and rushes. With his transfer to the Forest Service, there was more opportunity to concentrate on native range plants, and he produced major volumes on *Western Range Forbs* (1966), *Carices of the Rocky Mountains* (1970c), and *Carex in Mexico and Central America* (1974). During his lifetime, Fred Hermann's collection numbers (including bryophytes) came close to 30,000—almost entirely specimens from North America and Latin America.

Fred and Dorothy divorced in 1966, and six years later he married Nancy Irahola. He and Dorothy remained close friends until his death.

Despite his "great fun" with mosses in 1928, seven years later Fred wrote of William C. Steere, "his devotion goes to the mosses about which I am altogether ignorant." Nevertheless, mosses began to claim his interest in the 1950's, and after 1960 he gave almost all his spare time to them, continuing into his retirement, which officially began June 30, 1973, although he was "half-retired" for another year. With a sharp eye and strong floristic instincts, he added copiously to knowledge of moss distributions. For two



Figure 5. Fred and Nancy Hermann, with Fred's sister Olive Johnson, 1979.

years, 1977-1979, Fred served as honorary fellow and curator of bryophytes at the University of Wisconsin herbarium in Madison, where (with the loyal assistance of his wife) he labeled, packeted, sorted, annotated, and filed over ten thousand specimens in a collection that had lain uncured since the 1930's. His Wisconsin friends remember him as "quiet, gentle, and thoughtful, always a gentleman." His last publication, which appeared in print after his death, was a detailed list of the bryophytes of Rocky Mountain National Park, published in a volume honoring his former Michigan colleague, Bill Steere, on his 80th birthday. When Fred and Nancy finished

proofreading this final paper, he said to her in a satisfied manner, "It's done, now I am ready to die at any time."

Indeed, when his life—productive to its last days—came to an end on November 15, 1987, that marked the close of a career distinguished in several fields, the attainment of many goals, and orderly and thoughtful arrangements for the future. When preparing to return from Wisconsin to Colorado in 1979, Hermann presented the books and reprints of his valuable botanical library to the University of Wisconsin, and his *Carex* and *Juncus* herbarium (containing some other vascular plants as well; see *Taxon* 30: 866. 1981) to The University of Michigan along with his field notes. His bryophyte herbarium is now to come to Ann Arbor, too.

What may be Fred's last letter was written six days before he died, to Dr. Steere at New York, regretting inability to have been at the birthday celebration earlier in the month. "Congratulations on achieving your 80th year having so much to show for it!" he wrote, continuing by sharing a bit of history:

Perhaps you'd care for the enclosed postal card as a memento of Husnot. It was given me by his son-in-law and publisher, Auger, with whom I had considerable correspondence in his last years (we had bird-watching and philately in common). He died at 98, saddened that his deafness prevented him from enjoying bird-song any longer. . . .

What a prodigy was Husnot! Not only did he write, illustrate and lithograph classic manuals on mosses, hepatics, grasses, Cyperaceae, Juncaceae and weeds, but was mayor of his town and primarily a farmer . . . It would have been great to have known him. His keys to the bryophytes are among the best I've used. It's a shame that his *Muscologica Gallica* is so hard to come by, the result of 90 per cent of the edition having been destroyed by the allied bombing of his warehouse.

Cheers! And I hope you can carry on for many more joyful years.

Thoughtful letters to friends and suggestions of books or articles to read characterized Fred Hermann. Hobbies—if they can be called that—included birds and classical music. "His work will not end until we have traced each delicate web that ties us with all the life of the planet," writes his son Eric. "His greatest worry was that we will finish the planet before we finish that work. The world and its beauty belongs to all of us, not to politicians and mere ideologies. That our weapons could eradicate all life—plants, insects, mammals as much as man—was a terrible fear for him, and he worked hard, contributing hours and money, against that fear."

Robert Ireland, curator of bryophytes at the National Museums of Canada, knew Fred for 30 years and found him the most faithful of all his correspondents:

He was truly interested in me as a person and always found time to come to visit me regardless of how far I lived from his home. He was always an extremely kind and generous person who constantly helped me in my profession by checking literature references, writing Latin descriptions, donating bryophyte specimens to our herbarium, giving me botany books, and much more. Fred did things for me and numerous other people without expecting anything in return. One of the main things that I will remember Fred for was his gentle, quiet nature and his genuine concern for the well-being of creatures large and small.

Others would surely express similar sentiments if given the opportunity. His last letter to one of us (EGV) was a characteristic thoughtful one celebrating the appearance of the second volume—at long last—of *Michigan Flora*, causing him to “break into cheers, now that the botanical journals are so cluttered with . . . incomprehensible contemporary fads.” He began his last letter to the other of us (AAR), dated July 12, 1986: “The day you wrote me I was enjoying the breezes of Lake Superior at Copper Harbor, visiting with my sister from Marquette (my last trip; I’m told I’d better not travel any more) . . .” How Fred must indeed have enjoyed that last visit, at age 80, to the vast and wild inland sea of Lake Superior, the Copper Country in which he had grown up, the village of Copper Harbor on the rockbound shore, whence a box of coral-roots had gone to The University of Michigan in 1922.

ACKNOWLEDGMENTS

Fred Hermann’s principal goal upon deciding to become a botanist was to write a flora of Michigan. He became, as it developed, the leading authority on the great genus *Carex*. We who, as it turns out, are now producing a flora of Michigan (EGV) and researching primarily the genus *Carex* (AAR) have felt a good deal of vicarious pleasure, as well as sadness, in preparing this account. (Incidentally, both of us, like Fred, also began our plant collecting activities at the age of 16.)

Much information has been gleaned from the voluminous correspondence sent by Hermann (1936–1955) to Mr. and Mrs. Clarence Hanes of Schoolcraft, Michigan, and now in the Hanes files in the University of Michigan Herbarium archives. A folder of correspondence and documents in the H. H. Bartlett files has also been helpful, as has our own correspondence dating from 1949 (EGV) to 1986.

The cover photo and figs. 1 and 2 are from a set of 1930 photos in the Herbarium archives. We are especially indebted to Nancy Hermann and Eric Hermann for the other photographs, information, recollections, and encouragement. William A. Weber made a substantial contribution to compilation of the bibliography, and in other ways. Theodore Cochran, Howard Crum, Robert Ireland, Kenneth L. Jones, and others have been helpful. We are grateful to each. Had we tried to consult all possible documents and confer with all appropriate friends and colleagues, we would never have been able to complete this sketch of an unfolding and successful career.

PLANTS NAMED FOR FREDERICK J. HERMANN

Carex hermannii Cochrane (Brittonia 33: 228-231. 1981) [Type: Mexico]

Grimmia hermannii Crum (Michigan Bot. 13: 171-174. 1974) [Type: Michigan]

NEW TAXA NAMED BY FREDERICK J. HERMANN

Note: References are given by citing the publication as in the bibliography below, from which co-authors can also be determined. The type locality (country or state of the U. S.) is given after the reference. New combinations are not included.

Acacia pinetorum, nom. nov. (1948e, Florida)

Barbula rufofusca (1973d, Alaska)

Caesalpinia colimensis, nom. nov. (1948e, Mexico)

Cardamine uintahensis (1934, Utah)

Carex amplisquama (1955b, Georgia)

C. artitecta var. *subtilirostris* (1938, Indiana)

C. athabascensis (1975b, Canada)

C. atractodes (1950, Mexico)

- C. bicknellii* var. *opaca* (1972c, Arkansas)
C. bipartita var. *austromontana* (1963, Colorado)
C. caxinensis (1971, Guatemala)
C. chiapensis (1967, Mexico)
C. × deamii (1938, Indiana)
C. diehlii (1954a, Mexico)
C. distentifformis (1971, Mexico)
C. egglestonii var. *festivelliformis* (1960a, Mexico)
C. eurystachya (1957b, Canada)
C. fissa var. *aristata* (1965b, Florida)
C. foenea var. *tuberculata* (1968b, Washington)
C. guatemalensis (1971, Guatemala)
C. heteroneura var. *brevisquama* (1968b, Colorado)
C. incondita (1957b, Canada)
C. interior var. *keweenawensis* (1941a, Michigan)
C. laxiflora var. *serrulata* (1938, Indiana)
C. limnophila (1956c, Wyoming)
C. microptera var. *crassinervia* (1968b, Colorado)
C. muriculata (1949b, Texas)
C. parryana var. *brevisquama* (1968b, Colorado)
C. pelocarpa (1937d, Utah)
C. pensylvanica f. *androgyna* (1941a, Michigan)
C. percostata (1950, Mexico)
C. plectocarpa (1964c, Montana)
C. praticola var. *subcoriacea* (1957b, Canada)
C. quichensis (1950, Guatemala)
C. roanensis (1948b, Tennessee)
C. sartwellii var. *stenorrhyncha* (1938, Indiana)
C. stenoptila (1945, Colorado)
C. subbracteata var. *tolucensis* (1971, Mexico)
C. vallicola var. *hidalgensis* (1960a, Mexico)
C. vexans (1955b, Florida)
C. volcanica (1971, Mexico)
C. vulpinoidea var. *pynoccephala* (1936c, Michigan)
C. willdenowii var. *megarrhyncha* (1954a, Georgia)
Didymodon columbianus (1968a, Oregon)
Drepanocladus exannulatus f. *pseudotrichophyllus* (1977a, Colorado)
Eupatorium serotinum var. *polyneuron* (1938, Indiana)
Gyroweisia monterreia (1987a, Mexico)
Juncus abjectus (1948g, Oregon)
J. acuminatus f. *sphaerocephalus*, nom. nov. (1956b, California)
J. bryoides (1948g, California)
J. bufonius var. *occidentalis* (1978, Oregon)
J. capillaris (1948g, California)
J. hemiendytus (1948g, California)
J. howellii (1949d, California)
J. kansanus (1935b, Kansas)
J. leiospermus (1948g, California)
J. longistylis var. *scabratus* (1940k, Arizona)
J. macer f. *discretiflorus* (1938, Indiana)
J. megaspermus (1948g, California)
J. nodosus var. *meridianus* (1944c, Mexico)
Lonchocarpus calcaratus (1949a, Panama)
L. lasiotropis (1949c, Honduras)
L. nicou var. *languidus* (1947a, Colombia)
L. oliganthus (1949a, Panama)
L. resinosus (1949c, Mexico)
L. spectabilis, (1949c, Mexico)
L. venustus (1949c, Mexico)
Luzula echinata var. *mesochorea* (1938, Indiana)
Orthotrichum epapillosum (1973a, California)
Paraglycine (1962d)
Paraglycine sect. *Digitatae* (1962d)
Paraglycine sect. *Hedysaroides* (1962d)
P. madagascarensis (1962d, Madagascar)
P. unicastata (1962d, No. Rhodesia)
Phaseolus neglectus (1948e, Mexico)
× Pleuritrichum (1959a)
× P. marylandicum (1959a, Maryland)
Pontederia lanceolata var. *vichadensis* (1948a, Colombia)
Pseudoglycine (1962d)
Rubus parviflorus f. *pedatifidus* (1935c, Michigan)
Scirpus atrovirens f. *proliferus* (1938, Indiana)
Scleria vichadensis (1948a, Colombia)
Terua (1949c)
T. vallicola (1949c, Honduras)

BIBLIOGRAPHY OF FREDERICK J. HERMANN

We have checked all 122 titles listed below and believe this to be a complete record. A few widely distributed and often-cited mimeographed publications are included. However, a few other mimeographed documents of presumably limited distribution and ephemeral nature are omitted. We have, for instance, a 1936 transcript of a talk on "Wild Flowers of Michigan"

sponsored by the University of Michigan Broadcasting Service over station WJR in Detroit. More documents of such impermanent nature than we are aware of may well exist.

Hermann's personal bibliography (which was not complete for printed matter, as we have seen it) lists a 24-page mimeographed key to *Carex* in the Washington-Baltimore area (1941), a list of forage and ornamental species collected in 1956 in Canada, and three short items issued in 1943 by the Office of Foreign Agricultural Relations (which was established in the U. S. Department of Agriculture July 1, 1939, and abolished May 10, 1953). Two of these have the same titles as the 1944b and 1944c items below. The third was "Leguminous shrubs and trees used as shade and cover crops in tropical and subtropical countries" (17 pp.). A 1964 title listed without pagination or sponsorship, co-authored with R. S. Dyal and R. J. Ferretti, is "Physical and chemical properties, and botanical compositions of peats used as soil amendments in the USA." We have not been able to see any of these mimeographed items.

1928. The morphology and cytology of perfect flowers in *Populus tremuloides*. Pap. Michigan Acad. 8: 97-110 [with Eileen Whitehead Erlanson].
1931. The American egret in Manistee County, Michigan. Wilson Bull. 43: 311-312.
1934. A new Cardamine from the Uinta Mountains, Utah. *Rhodora* 36: 409-412 + pl. 322.
- 1935a. *Naias marina* in hot springs. Leaflet. West. Bot. 1: 182.
- 1935b. The distribution of *Juncus* in Kansas. Pap. Michigan Acad. 20: 37-47.
- 1935c. A mutation in *Rubus parviflorus*. *Rhodora* 37: 59-61 + pl. 326.
- 1935d. *Festuca sciurea* in New Jersey. *Rhodora* 37: 266-267.
- 1935e. *Eleocharis caribaea*, var. *dispar* in Michigan. *Rhodora* 37: 366-367.
- 1936a. The genus *Carex* in Kansas. Am. Midl. Nat. 17: 849-865.
- 1936b. Additions to the flora of Washtenaw County, Michigan. Pap. Michigan Acad. 21: 81-87.
- 1936c. Notes on the flora of Michigan, I. *Rhodora* 38: 362-367.
- 1936d. Diagnostic characteristics in *Lycopus*. *Rhodora* 38: 373-375 + pl. 439.
- 1937a. Additions to the flora of Chippewa County, Michigan. Pap. Michigan Acad. 22: 85-89.
- 1937b. Additions to the flora of Washtenaw County, Michigan. II. Pap. Michigan Acad. 22: 91-94.
- 1937c. *Cladium mariscoides* in Saskatchewan. *Rhodora* 39: 232.
- 1937d. Extensions of range and a new species in *Carex*. *Rhodora* 39: 491-495.
1938. New or otherwise interesting plants from Indiana. *Rhodora* 40: 77-86.
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REVIEW

GRAY'S MANUAL OF BOTANY. 8th ed. By Merritt Lyndon Fernald. [facsimile reprint] Dioscorides Press, Portland, Oregon. 1987. 1xiv + 1632 pp. \$59.95 + \$3.00 shipping & handling (9999 S. W. Wilshire, Portland 97225).

A few years ago, the publishers of this great work allowed it to go out of print, creating what may well have been the first prolonged period since 1848 that botanists could not walk into a bookstore and buy (or order) a copy of Gray's *Manual*. The 8th edition, published in 1950, was reprinted several times and always at a scandalously increased price. The 1970 printing finally included many corrections, assembled by Reed C. Rollins, and it is that corrected printing which is now available in a welcome facsimile reprint. My original copy, purchased in 1950 for \$9.50, required sturdy rebinding in 10 years. The binding in the present reprint looks hardly durable enough to last 10 months. The paper is thicker (adding nearly a pound to the weight) but has more show-through than in the first printing, giving the pages a muddy look where type on the other side is visible. Nevertheless, it is occasion for rejoicing that this valuable manual is again in print—albeit at over a 6-fold price increase from 1950. It has more detailed information than its chief competitor (itself now undergoing thorough revision), and it will long be useful at least as a supplement to any other work dealing with the flora of northeastern North America.

The 1970 corrected printing attended mainly to errors in metric units, erroneous cross-reference numbers, a couplet (in *Viola* key) lacking one lead, and other serious problems. It mostly did not correct wrong type faces, misspelled authors' names, misplaced accent marks, and such trivial errors. Nor did it deal with omitted species, faulty descriptions, inadequate ranges, or other questions of content. It did not repair keys that don't work, words used in a sense contradictory to the glossary (e.g. *resupinate*, pp. 464 and 476), illogicalities like characters of filaments given under a key to pistillate material (p. 656), hollow phrases like "often yellow (or not)" (p. 1358), redundancies like "flower (including corolla)" (p. 1286), geographic obsolescence like "Nfld. and Canada" (p. 477). Such problems inevitably continue in the facsimile, where they can continue to charm, entertain, or frustrate users.

—E. G. Voss

REVIEW

GROWING AND PROPAGATING WILD FLOWERS. By Harry R. Phillips. Edited by C. Ritchie Bell and Ken Moore; illustrations by Dorothy S. Wilbur. University of North Carolina Press, Chapel Hill, North Carolina and London. 1985. 331 pages, 250 + illustrations including 32 color photographs. \$24.95 hardbound, \$14.95 paper.

Because of increased interest in gardening with wildflowers and decreasing space from which to collect plants, this book, with its theme of conservation of wildflowers through propagation, is timely. The information given is based on ten years of team work in propagating wildflowers at the North Carolina Botanical Gardens. As a result the information and directions are detailed, accurate, practical, and easily understood.

Part 1, Cultivating Native Plants, includes fundamentals of soil preparation, maintenance, planting through the seasons, designing the garden, and pests and diseases. Part 2 on propagation gives instructions on the collection, cleaning and storage of seeds, dormancy and pregermination techniques, sowing seed, and transplanting seedlings that should enable even a novice to be successful. Asexual propagation by division and stem and root cuttings are also explained.

The main body of the work is devoted to detailed information on nearly 100 native and naturalized species, including special chapters on carnivorous plants and ferns. For each species line drawings, a description of the plant, fruit, and seed; directions for collecting, cleaning, and storing seed; special propagation and cultivation notes; and suggested uses in the garden and landscape are given. Cultural notes on some related species add to the usefulness of the book.

The four appendices include how to organise a plant rescue, a calendar of blooming dates, a production timetable for commercial growers, and a guide to recommended literature. A glossary and index to common and scientific names (including scientific names of the related species mentioned) complete the book. The section entitled "Glossary and Plant Physiology" puzzles me. The glossary is well done and easy to understand and many of the terms are illustrated, but I can detect nothing about plant physiology in it!

The book is well written, easy to understand and very informative. It gives those little tips that often make such a difference between success and failure. This book can be highly recommended for use wherever the included species occur; however, the blooming dates and associated species may differ outside the southeast.

The concept of conservation through plant propagation is laudable. Even a small flower bed can be planted to a variety of wildflowers. Three designs for wildflower gardens are given which would be acceptable even where laws prohibit the growing of the naturalistic type of wildflower garden. People who have woodlands, or live where the height of "weeds" are unregulated, can grow the natural type garden. Whichever type is grown, wildflowers are added to our environment and many scare species can be multiplied and shared with others.

—Helen Smith

245 DETECTING BOTRYCHIUM HYBRIDS IN THE LAKE SUPERIOR REGION

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The two best known nothospecies of *Botrychium* s.l. are *B. (Sceptridium) × longistipitatum* Sahashi and *B. (Botrychium) × watertonense* Wagner. The former was the first of several hybrids found in a dark *Camellia* forest on Oshima Island in the Izu Islands south of Tokyo. It is evidently the cross of *B. atrovirens* ($n = 135$) and *B. ternatum* ($n = 45$); the chromosomes show irregular pairing (Sahashi 1979, 1982). The latter, *B. × watertonense*, is known from a snowfield area in Waterton Lakes National Park, Alberta, Canada, where we have observed more than 100 plants of it. Without doubt the hybrid of the two tetraploid orthospecies, *B. hesperium* and *B. paradoxum*, it is remarkable for combining the very different leaf morphologies of the parents. Meiosis in the hybrid is irregular (Wagner et al. 1984), and the spores are abortive, as in practically all primary pteridophyte hybrids. In addition to these two, there are twelve other interspecific hybrids reported in Scandinavia, North America, and Japan (Wagner et al. 1985), as well as two more to be briefly described here. It should be mentioned that Jermy & Walker (1977) and Sahashi (1982) also reported triploid intraspecific hybrids in *B. (Japanobotrychium) lanuginosum* in Malaysia.

Unfortunately our methods of studying natural populations of *Botrychium* thus far do not favor the detection of hybrids per se. What we generally seek if we are searching for hybrid ferns is, of course, intermediate character states, association with parents, and particularly evidence of disruption of the chromosome apparatus, either directly by cytological observation or indirectly by the detection of abortive spores (Wagner 1980, Wagner et al. 1986). It is important to use specimens of parents from the same time and place for comparison with the hybrids, because the plants are extremely changeable according to stage of development (e.g., relative size of sporophore) and habitat (compact forms in open places; lax forms in shaded places). Except in the case of *B. × watertonense* we have not used field methods designed to detect hybrids.

Our routine study methods are primarily concerned with establishing the taxon boundaries and taxonomic status of the species. They involve the following steps: (1) locate populations of botrychiums; (2) determine whether more than one taxon is present (usually the case); (3) if so, determine whether the taxa are growing in close association, within a couple of feet of each other; (4) collect a complete census of leaves only, often involving hundreds (not removing the stems and roots, however, so that the colony will remain intact). Most of our collections have been made by

anywhere between two and twenty persons, some of them novices at collecting botrychiums. Once the mixed population sample has been made, it is painstakingly studied before pressing—the specimens are separated into taxa, notes taken on color, variations, etc., and then pressed. It is only at this stage that we detect any hybrids that may be present, too late to mark the plant in its native habitat for later study. In connection with the putative hybrids to be described here, we hope to relocate these plants for cytological and/or isozyme analyses. We want, by presenting this article, to encourage others not only to make local population censuses of leaves, but also to watch for interspecific hybrids.

Truly intensive studies of botrychiums have not been made previously in the western Great Lakes region, herein defined as northern Michigan, Wisconsin, Minnesota, U.S.A., and Algoma and Thunder Bay Districts, Ontario, Canada. We were originally stimulated to make such studies after Joseph M. Beitel discovered the prairie dunewort, *B. campestre* Wagner and Farrar, in the dunes of northern Michigan in 1982. In the years following we have made many surprising discoveries, including major disjunctions of western species and several new species. (The situation is similar to that of the orchid genus of ladies'-tresses, *Spiranthes*, in which workers like Catling, Sheviak, Cruise, and Case, have recently opened up a whole new vista of their taxonomy. Cf. Case 1987, pp. 163-187.) The results of our field work and that of our colleagues have yielded hundreds of new specimens from many localities, so it is not surprising that we have encountered the peculiar specimens to be described briefly below. We give them only formula names, because none of them has been found in sufficient numbers thus far to warrant nothobinomials. Character states said to resemble one of the parents are usually only partially expressed.

a. *Botrychium matricariifolium* \times *minganense* (Fig. 1a). On casual inspection the living plant resembles a form of *B. minganense*. However, when we examined all of our *Botrychium* collections from the locality, we realized that it was this hybrid combination. The spores, of course, are highly abortive, and the plant appears to be an excellent intermediate between the proposed parents. Character states suggestive of *B. matricariifolium* are (a) the midribbed pinnae, and (b) the pinnulate or deeply lobed pinnae. Those suggestive of *B. minganense* are (a) the sublinear trophophore blade outline, and (b) the subflabellate to spatulate to linear upper pinna pairs. The specimen is of approximately the same size as the two parents at this locality and time, an open field along Haywire Railroad Trail in Schoolcraft Co., MI (T42N, R16W, SE $\frac{1}{4}$ of Sec. 36), 30 June 1981, Wagner 81045 (MICH). Other Ophioglossaceae found in the same field were *B. lanceolatum*, *B. lunaria*, *B. multifidum*, *B. simplex*, *B. virginianum*, and *Ophioglossum pusillum*.

b. *Botrychium lanceolatum* \times *matricariifolium* (Fig. 1b). At first sight this looks like a broad form of *B. lanceolatum*. However, when we received from its discoverer materials of *B. lanceolatum* and *B. matricariifolium* found growing with it, we recognized its hybrid nature and confirmed it by examination of its spores. The hybrid differs from eastern *B. lanceolatum*

(*B. l.* var. *angustisegmentum* Pease and Moore) in having (a) segments approximately two times as broad, (b) larger pinna lobes, (c) more yellowish color, and (d) more strongly stalked sporophore—all states pointing to *B. matricariifolium* parentage. Plants of the parents were collected at the same time in a forest, and represent, as does the hybrid, deep shade forms. The plants were found in an old, closed forest nine miles west of Munising, Alger Co. MI (T46N, R20W, NW¹/₄ of Sec. 16) by Don Henson (no. 2300, MICH) on 29 June 1987.

c. *Botrychium matricariifolium* \times *simplex* (Fig. 1c). This combination was discussed in detail earlier (Wagner 1980) and is briefly described and figured here for sake of completeness. It differs from typical *B. matricariifolium* in the following characters that approach *B. simplex*: (a) the long trophophore stalk, (b) the strongly enlarged basal pinnae, (c) the wider pinnae and pinnules, and (d) the subflabellate rather than oblong or deltoid upper pinnae. Details of the occurrence of the hybrid were given in the earlier paper. Recent visits to the localities failed to yield any additional hybrid plants.

d. *Botrychium lunaria* \times *simplex* (Fig. 1d). We know less about the circumstances of occurrence of this plant than any of the others. It is known to us from a single plant on a herbarium sheet. The frond cutting is different from any moonwort that we have studied. The plant looks superficially like a monstrous *B. lunaria*, and it seems very likely that this is one of the parents. The most plausible other parent is *B. simplex*. If it were *B. matricariifolium*, the blade would probably be more divided and the segments narrower and smaller. Character states that indicate *B. lunaria* are (a) the few, coarse, more or less flabellate upper pinnae; (b) the wide angle formed by the lateral margins of second and third pinna pairs; and (c) the finely divided tip with linear segments. Those that indicate *B. simplex* are (a) the enlarged basal pinnae (but not so enlarged as in *B. matricariifolium* \times *simplex*), (b) the pinnulate first and second pinna pairs, and (c) the asymmetrical third and fourth pinna pairs. The identification on the label of "*Botrychium multifidum*" illustrates how confusing the specimen must have appeared to earlier observers. The label data are given as "Escanaba County: In field along millpond of sawmill. R. B. Wilson, 17 June 1964". The data should probably read "Delta Co., Escanaba," as there is no Escanaba County in Michigan. The specimen in question is in the Beal-Darlington Herbarium of Michigan State University (MSC).

e. *Botrychium lunaria* \times *minganense* (Fig. 1e). The two species involved in this combination are frequently confused by field botanists. However, *B. lunaria* is widespread in the New and Old Worlds and in both northern and southern hemispheres. It is a remarkably uniform plant. *Botrychium minganense*, on the other hand, is known only from northern North America, and is strongly variable and possibly a species complex. We found a number of plants of their hybrid in a large mixed collection of *B. lunaria* and *B. minganense* (*sensu lato*) where they were growing together in a shrubby area near railroad tracks. At first sight the plants look like a broad form of *B. minganense*. They share with that species (a) a rather

long-stalked trophophore, (b) the somewhat ascending pinnae, and (c) the pinnae narrower than in *B. lunaria*. The hybrid shows the effects of *B. lunaria* in (a) overlapping or approximate pinnae, and (b) the finely cleft apex. The character states given are intermediate between the parents, but express the partially developed special states of one or the other parent. Apparently conditions are just right at this site for hybridization, for we obtained eight specimens of the intermediates. The spores are abortive in all of them. The locality is in the Thunder Bay District, Ontario, on the north side of the Canadian Pacific railroad tracks in a habitat of scattered small trees (especially *Populus*) and shrubs, near the old Angler Settlement west of Marathon, *Wagner 87237*, 30 June 1987 (MICH).

DISCUSSION

The specimens, as shown in Figure 1, are troublesome even to persons thoroughly familiar with the genus. They simply do not "fit" our ideas of any known species. They would be difficult to key out. Figure 1a is representative of neither *B. matricariifolium* nor *B. minganense*, and the same is true of the other intermediates—they do not fit either of their supposed parents. It is possible that some of our diagnoses may be incorrect, although on present evidence the ones we have given are the most likely. We need more studies of natural hybridization. We have not concentrated on natural hybrids because we have been primarily concerned with identifying the basic species which themselves may be difficult to identify. Even expert pteridologists have confused specimens of *B. lanceolatum* with *B. matricariifolium*, *B. lunaria* with *B. minganense*, and small specimens of *B. lunaria* with large specimens of *B. simplex*. However, we may be able to gain more insights into species differences by studying their hybrids. To what extent are moonwort species obligately inbreeding? Are there still undiscovered apomictic methods of reproduction that account for genetic uniformity of some populations? When we find numerous examples of certain hybrids (e.g., *B. × watertonense* or *B. lunaria × minganense*) are we simply dealing with inherited tendencies toward apomixis, reproduction by roots, stems, gemmae, or unreduced spores? Perhaps these are not separately produced by crossing, but simply by cloning of one initial hybrid.

Whatever the case, using our methods of studying natural populations of *Botrychium*, the number of hybrid plants we detected is probably a good measure of their incidence in a mixed population of parents. The problem of establishing with certainty that the plants in question are truly interspecific hybrids is still before us. The pattern of intermediacy, association with parents, and spore abortion is so well established in ferns that any other explanation for the peculiarities of the plants described here seems very unlikely. Nevertheless, it would not be a fair statement to say that there is no question at all about them, especially the one diagnosed as *B. lunaria × simplex* for which we have no evidence of the associated species. The main problem with recognizing *Botrychium* hybrids is that some normal orthos-



Figure 1. Intermediate, sterile botrychiums from Michigan and western Ontario. a. *B. matricariifolium* \times *minganense*. b. *B. lanceolatum* \times *matricariifolium*. c. *B. matricariifolium* \times *simplex*. d. *B. lunaria* \times *simplex*. e. *B. lunaria* \times *minganense*.

pecies are so variable that individual specimens may vary in the direction of a sister species. Large divided forms of *B. simplex* with oblong fronds are commonly identified as *B. lunaria* or *B. minganense*; broad deep-shade forms of *B. matricariifolium* as *B. lanceolatum*; large-lobed forms of *B. multifidum* as *B. oneidense*; and pointed lobed forms of *B. bitermatum* as *B. dissectum*. All of these have normal spores. There is no question that true hybrids do occur. We now have 16 proven or suspected hybrids. Even in Europe, with its depauperate *Botrychium* flora (only *B. boreale*, *B. lunaria*, *B. lanceolatum*, *B. matricariifolium*, *B. multifidum*, *B. simplex* and *B. virginianum*), hybrids between *B. boreale* and *B. lunaria* are quite numerous, at least in Scandinavia. This cross is surprisingly difficult to detect on superficial inspection because it looks like a blunt-lobed *B. boreale*. On the basis of what we know now, wherever members of the same

subgenus co-occur in the same habitats, efforts should be made to determine whether hybridization is occurring between them.

ACKNOWLEDGMENTS

This study was made in connection with NSF Grants DEB800536 and DEB8202768, Monograph of *Botrychium*; and two research grants from the Nongame Wildlife Fund of the Michigan Department of Natural Resources. The Naturhistoriska Riksmuseum, Stockholm (S), kindly lent us a large series of European botrychiums for the detection of hybrids. We wish to acknowledge with many thanks all of the persons who have helped us make population samples. We are also grateful to J. M. Beitel, Don Henson, and A. Reznicek for their assistance in various ways.

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**FROELICHIA (AMARANTHACEAE), A GENUS
NEW TO CANADA**

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Froelichia gracilis (Hook.) Moq., cottonweed, is native in sandy soil from Iowa to Colorado, southward to Arkansas, Texas, New Mexico, and Mexico; it is widely adventive eastward to Wisconsin, Illinois, Indiana, Michigan, Ohio, New York, Pennsylvania, New Jersey, Maryland, Virginia, Kentucky, North Carolina, South Carolina, Georgia, Alabama and Mississippi (Blake 1956, Sauer and Davidson 1961, Reed 1962, Robertson 1981, Voss 1985). It has not previously been reported from Canada (Boivin 1966, Scoggan 1978). In areas where it is introduced, *F. gracilis* is almost exclusively found along railway tracks. *Froelichia floridana* (Nutt.) Moq., the only other member of the genus in eastern North America, occurs from Delaware, New Jersey, Indiana, Minnesota, South Dakota, and Colorado, south to Florida, Mississippi, and Texas (Robertson 1981).

Froelichia gracilis is distinguished from other species in the genus by its asymmetrically conical fruiting perianths less than 4 mm long with crests of lateral rows of distinct spines, tan colored seeds, leaves mostly 5 to 10 mm wide, and stems much branched from the base (Robertson 1981). Although the inflorescence of *Froelichia* is quite distinctive (Figures 1 and 2), the peculiar flower structure can make identification difficult for those unfamiliar with the genus. The anther filaments are fused into a tube bearing the anthers, making the flower look exactly like it has a corolla of fused petals with epipetalous stamens (A. A. Reznicek, pers. comm.). This can make *Froelichia* difficult to key out using some family keys.

On 17 September 1983, *F. gracilis* was found along the Conrail (formerly Michigan Central) Railway, 2 km. northeast of the town of Essex, 20 km southeast of Windsor, in central Essex County, Ontario (Oldham 4074, CAN, MICH, TRTE). It was well established at the site, with many thousands of plants growing in cinders for about 100 m on both sides of the tracks (Figures 1 and 2). Major associates of *F. gracilis* at this site included *Polanisia dodecandra* (clammy-weed), *Panicum capillare* (witch-grass) and *Linaria vulgaris* (butter-and-eggs). This population has persisted at this location for the past four years, and appears to have been present for several years prior to its discovery. Despite many searches along this and other railway lines in Essex County, no other populations have been found.

Along the same Conrail Railway, 214 km to the east, *F. gracilis* was discovered on 28 August 1985 near Windham Centre, 30 km south-southwest of Brantford, Haldimand-Norfolk Regional Municipality (Sutherland 6531, CAN, DAO, TRTE, WAT). At Windham Centre several hun-



Figure 1 (left): *Froelichia gracilis* growing in cinders beside the Conrail Railway, Essex County, Ontario, 24 July 1984.

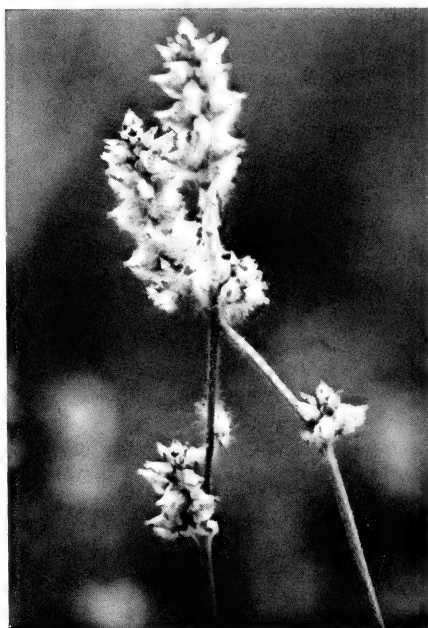


Figure 2 (right): Close-up of inflorescence.

dred plants grew on sand and cinders scattered for about 100 m along the edge of the railway ballast. Common associates included *Ambrosia artemisiifolia* (common ragweed), *Salsola kali* (Russian thistle), *Potentilla inclinata* (cinquefoil), *Setaria glauca* (foxtail), *Setaria viridis* (foxtail), *Amaranthus powellii* (pigweed), *Panicum capillare* (witch-grass), *Sporobolus vaginiflorus* (dropseed), *Poa compressa* (Canada bluegrass) and *Saponaria officinalis* (bouncing bet).

Searches along railway tracks elsewhere in Haldimand-Norfolk did not reveal additional population, nor did searches in the intervening counties of Kent and Elgin. *Froelichia gracilis* does, however, occur 128 km east of the Windham Centre locality in Buffalo, New York. A small colony of about two dozen plants discovered in 1980 by R. A. Klips in the Buffalo Central Railway Terminal is the only record for the Niagara Frontier Region (Klips and Zander 1985). To the west, *F. gracilis* has been found in St. Joseph and Berrien Counties in southwestern Michigan (Voss 1985). In view of the recent discoveries in Essex County and Haldimand-Norfolk Regional Municipality, *F. gracilis* should be looked for along the Conrail and other railways in southwestern Ontario.

SUMMARY

Froelichia gracilis (Hook.) Moq., cottonweed, is reported from Essex County and Haldimand-Norfolk Regional Municipality in southwestern Ontario, new to the flora of Canada. At both sites the species occurs along a railroad, as it does at most stations in the eastern portion of its range.

ACKNOWLEDGEMENTS

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REVIEW

DICTIONARY OF PLANT NAMES. By Allen J. Coombes. 207 pp. Timber Press. 1985. \$9.95 + \$2.25 shipping charges. (9999 S. W. Wilshire, Portland, Oregon 97225.)

Many botanists no doubt have been faced with the desire to answer two questions about the scientific name of a plant: the derivation of the name and what common name may apply to the plant. The title *Dictionary of Plant Names* implies that this should be an ideal source for such information, especially in combination with the descriptive phrase on the cover: "The pronunciation, derivation and meaning of botanical names, and their common-name equivalents." Indeed the book does live up to that billing, but only on a limited scale. The first sentence of the Introduction reveals that the author has aimed to provide information on "the more commonly grown plants"; that would eliminate most of our familiar wild flora. What may not be immediately apparent is that the author is referring to plants commonly grown in England, not the United States. Much of the research for the book was performed at the library of the Royal Botanic Gardens at Kew and the book was initially published in England in 1985.

After a brief introduction, a two-page pronunciation guide, and a two-page glossary, the remainder of the book is, as the title implies, a dictionary. Entries are one of two types: common names (cross referenced to a scientific name) or generic names. The common problem of indexing multiple word common names appears here; Japanese Larch appears only under "Larch, Japanese" while there is listing for the Japanese Foam Flower under "Foam Flower." Within a genus entry, one finds a pronunciation guide, the family to which it belongs (no clue on what classification system is followed), origin of the name, one-to-several words about the plant habit, "a general guide to hardiness," and sometimes a common name applied to the genus and country of origin of the plant. Commonly cultivated species are listed alphabetically under a genus with similar information included about each listed species. Intraspecific names and/or horticultural names are sometimes given and likewise described; infraspecific names are listed as unranked trinomials while horticultural names are segregated into cultivars and groups.

While this volume cannot replace the more complete, but now out-of-print, Smith's *A Gardener's Dictionary of Plant Names*, Coombes' *Dictionary of Plant Names* is worthy of a place on a botanical bookshelf. The indexing of common names and genera together allows one to start at either name and obtain the derivation of the scientific name. Listings under many of the genera provide clues on taxa that one might find in cultivation. If only it was as comprehensive as the title suggests . . .

—R. K. Rabeler

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EURASIAN INTRODUCTIONS TO THE
MICHIGAN FLORA. IV.
TWO ADDITIONAL SPECIES OF
CARYOPHYLLACEAE IN MICHIGAN.

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A recent treatment of the Caryophyllaceae known to occur in Michigan is presented in *Michigan Flora, Part II* (Voss 1985). Two species, *Cerastium pumilum* Curtis and *Stellaria pallida* (Dumort.) Piré, can be added to that list.

Cerastium pumilum Curtis

Curtis' Mouse-ear Chickweed

There have been few reports of *Cerastium pumilum* in eastern North America. It is mentioned in all three of the major northeastern manuals; Fernald (1950) and Maguire (1952) report it from southern New Jersey, while Gleason & Cronquist (1963) noted it as "reported in our range." *Cerastium pumilum* has been reported in several recent state and/or local floras: Missouri (Steyermark 1963); Illinois (Mohlenbrock 1975, 1986); Berks County, Pennsylvania (Wilkens 1975); New Jersey (Hough 1983); Maryland (Brown & Brown 1984), and Manitoulin Island, Ontario (Morton & Venn 1984).

Cerastium pumilum can be added to the flora of Michigan on the basis of the following collections:

MICHIGAN. INGHAM CO.: Curb edge, Okemos Community Church lawn, N side of Methodist St., 30 meters E of Okemos Rd., Okemos, T4N, R1W, SE $\frac{1}{4}$ of Sec. 21, 3 May 1985, *Rabeler 864* (MICH, MSC, NY); lawn between sidewalk and parking ramp, N side of West Kalamazoo St., W of South Capital Avenue, Lansing, T4N, R2W, SW $\frac{1}{4}$ of Sec. 16, 16 May 1986, *Rabeler 913* (BLH, GH, MSC). VAN BUREN CO.: Gravel shoulder, S side of eastbound I-94, near Mile 65, W of Mattawan, T3S, R13W, SW $\frac{1}{4}$ of Sec. 11, 11 May 1985, *Rabeler 868* (MSC). WASHTENAW CO.: near fire hydrant, W side Beal Ave., SE of W. E. Lay Automotive Laboratory, University of Michigan North Campus, T2S, R6E, NE $\frac{1}{4}$ of Sec. 22, 5 Jun 1987, *Rabeler 942* (DAO, MICH).

Identification of *Cerastium pumilum* is complicated by its similarity to *C. semidecandrum* (Small Mouse-ear Chickweed). Both are small annual plants bearing tiny flowers with white, shallowly-notched petals, and five (rarely 10) stamens. The petal, sepal, and seed measurements given for *C. semidecandrum* in Voss' (1985) key to the species of *Cerastium* would also apply to the above collections of *C. pumilum*.

Several qualitative features can be used to separate the taxa. A rarely cited distinction involves the seed surface; seeds of *C. pumilum* are covered with minute acute or blunt papillae, while those of *C. semidecandrum* are

virtually smooth or with a few rounded papillae [see Berggren 1981; not always as suggested by Fernald's (1950) tiny text illustrations]. The petal veins of *C. pumilum* are forked while those of *C. semidecandrum* are simple and unbranched. One of the most distinctive features of *C. semidecandrum* is the presence of a wide scarious margin on the inflorescence bracts. Up to one-half of the uppermost bracts can be scarious tissue. Inflorescence bract margins of *C. pumilum* are at best narrowly-scarious with the lowermost bracts sometimes lacking a scarious margin (as in *Rabeller* 913 and 942). Pedicels of *C. semidecandrum* are usually deflexed in fruit, while those of *C. pumilum* remain erect.

The presence of *C. pumilum* in disturbed habitats in Michigan and the report by Morton & Venn (1984) of the species from nearby Manitoulin Island, Ontario both suggest that *C. pumilum* should be found elsewhere in Michigan.

Stellaria pallida (Dumort.) Piré

Lesser Chickweed

This binomial has appeared on only three previous occasions in North American botanical literature. Morton (1972) reported *Stellaria pallida* as new to North America after he collected it near Kitty Hawk, North Carolina. Wilkens (1975) listed *S. pallida* in his floristic check-list of Berks County, Pennsylvania. Kartesz & Kartesz (1980) included *S. pallida* in their North America Checklist although it does not appear in the *National List of Scientific Plant Names* (Rice et al. 1982).

Stellaria pallida can be added to the flora of Michigan on the basis of the following collections:

MICHIGAN. INGHAM CO.: dry ground adj. to steam tunnel grating, near SE corner of Biochemistry Building, Michigan State University Campus. T4N, R1W, NW¹/₄ of Sec. 19, 22 Apr 1985, *Rabeller* 907 (BLH, GH, MICH, MSC). WASHTENAW CO.: lawn, N side of S vertical tower, SE corner of W. E. Lay Automotive Laboratory, University of Michigan North Campus, T2S, R6E, NE¹/₄ of Sec. 22, 21 May 1987, *Rabeller* 941 (MICH, MSC, NY).

Identification of *Stellaria pallida* is likewise complicated by close resemblance with another species, in this case the ubiquitous *Stellaria media* (Common Chickweed). Plants of both species would key out as *S. media* in Voss (1985) since both possess ovate (but not "broadly ovate" in *S. pallida*) leaves, the lower ones distinctly petiolate.

I have found several of the diagnostic features noted by Morton (1972) to be particularly useful. The combination of yellowish-green foliage, and flowers that are usually apetalous and cleistogamous with calyces about 3 mm long and capsules 3 - 4 mm long, separates *S. pallida* plants from all but the smallest plants of *S. media* which, unfortunately, are often found at similar (if not the same) sites. Seed features furnish a consistent means of distinguishing *S. pallida* from *S. media*. Seeds of *S. pallida* are yellow-brown, up to about 0.8 mm in diameter, and covered with tiny acute papillae that give the margin of the seed a prickly appearance. *Stellaria media* seeds are usually darker brown, only rarely smaller than 0.9 mm in diameter, and

covered with larger, more blunt papillae that produce a wavy margin [see comparative photos in Morton (1972) and Berggren (1981)].

I have found two other characteristics that, when present, are useful in recognizing *Stellaria pallida*. A red band is present at the base of the calyx in a majority of flowers on most, but not all, of the specimens that I have examined from Michigan, the southeastern United States, and from its native environs in England. I have yet to discover an *S. media* flower with a similar basal calyx band. The second feature involves the position of the ripe capsule. In *S. pallida*, the pedicels elongate and bend as the capsule is developing, eventually holding the ripe capsule erect. An examination of *S. media* plants will reveal that while the pedicels also elongate during capsule maturation, the pedicel normally bends downward, the capsule thus pointing toward the ground. In this case, the exception lies in the behavior of some early spring *S. media* plants, occasional specimens of which have nearly erect capsules.

Stellaria pallida is likely to be found elsewhere in Michigan. The following quotation concerning the paucity of records of *S. pallida* in a portion of its native range (the Isles of Scilly, England) is most applicable to its occurrence in Michigan: "No doubt more frequent than these records indicate but it flowers in March and April [April and May here] and disintegrates before most botanists arrive" (Lousley 1971).

ACKNOWLEDGMENTS

I thank the curators of GH, MICH, MO, and MSC for the use of their collections and John K. Morton for sharing his thoughts on *Stellaria pallida* and for allowing me to inspect his collections of these plants in North America and England.

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**COMMELINA ERECTA (DAY-FLOWER)
REDISCOVERED IN MICHIGAN**

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Commelina erecta L. (Day-flower) is cited by Voss (Michigan Flora, Part I. Cranbrook Inst. Sci. Bull. 55. 1972) as not being collected in Michigan since the First Survey on 25 August 1838, in Cass Co., on the banks of a small lake. More recently, Beaman, et al. (Mich. Bot. 24: 111. 1985) have listed the plant as probably extirpated. The taxon was collected in June and July of 1981 in Niles township (mistakenly labeled Bertrand township), Berrien Co, Michigan in a disturbed area (Ng 279; AUB; MSC) and near an "old dumpsite" (Ng 758:AUB). The collecting sites were in sandy soil near State Line Road separating Indiana and Michigan in an oak savanna woodlot which was in various stages of succession.

The disturbed nature of the area caused by periodic off-road vehicles (ORV's) and the presence of a small old, overgrown dumpsite with trees at least 20 years-old (determined by increment bore samples) raises questions about the species being introduced. This answer may never be known. However, because the previous known specimen could be interpreted as being from a relatively disturbed habitat ("banks of a small lake"), it stands to reason that this species might be present in other habitats in SW Michigan. A check of floras from within the plant's distribution, indicates the species is found in "dry, usually sandy soil" or "dry woods and rocky outcrops". It would not be surprising to see this long-sought-after species turn up in collections from habitats other than that indicted at the original early collection.

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**MOLINIA CAERULEA, MOORGRASS,
NEW TO WISCONSIN**

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Molinia caerulea (L.) Moench, moorgrass, is native throughout Europe (Tutin 1980) and into central Asia (Tselev 1983). It is common in European bogs, often in acidic peat with moving soil water (Jeffries 1915; Gore & Urquhart 1966) and often associated with *Sphagnum recurvum* P. Beauv. and *Polytrichum commune* Hedw. (Clymo & Hayward 1982). Moorgrass was introduced into the northeastern United States around 1940 possibly in commercial seed (Dix 1945). It is locally established in Newfoundland and from eastern Maine to Pennsylvania (Fernald 1950) and also in Quebec and eastern Ontario (Dore & McNeill 1980). Dix (1957) noted its persistence in old fields in Pennsylvania more than a decade after its introduction, and that it formed large clumps of 12–20 culms with a root mass over a foot in diameter. A less-vigorous form, "Cv. Variegata," with striped green and cream-white blades, is in cultivation and available through several nursery catalogs.

On September 22, 1986 a collection of *Molinia caerulea* (Bowers & Echola 11927, UWSP) was made in the West Scott Marsh bog, T19N, R1E, SW¹/₄ of Sec. 4, Monroe Co., Wisconsin. Sphagnum for horticultural packing had been harvested from this bog in 1984 and 1985. The bog in 1986 was dominated by sedges and rushes making the 25–30 large clumps of moorgrass with culms over a meter tall quite conspicuous. The source of this *Molinia* population is not apparent. This bog and the surrounding land are owned by the Wisconsin Department of Natural Resources and have remained relatively wild except for the sphagnum harvesting. This appears to be the first record of *Molinia caerulea* for Wisconsin and the Midwest.

The distinguishing features of moorgrass include large clumps of tall, slender culms, narrow panicles, and two well-separated florets per spikelet with the lower half of the paleas curving outward against the rachilla.

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NEW FEATURE: NOTEWORTHY COLLECTIONS

We have decided to implement a new feature in *The Michigan Botanist* entitled Noteworthy Collections. The purpose of this section will be to provide, as an alternative to a formal paper, a convenient place for brief reports of significant plant collections in the Great Lakes Region. Each submission will be reviewed by a specialist on the plant family and/or regional flora. A voucher specimen must be deposited in a public herbarium. The format presented below should be followed when preparing entries for Noteworthy Collections.

STATE or PROVINCE

Species Author(s) (Family). Common Name (if known).

Previous knowledge. Intended to summarize the knowledge of the taxon in the Great Lakes region prior to this report. Include herbaria and literature references consulted in preparing your information.

Significance of the report. Document the importance of the collection. Include herbaria and literature references as deemed necessary, abbreviating literature and herbaria as noted above.

Diagnostic characters. An optional entry for inclusion of information on recognition of the taxon, separating it from closely-related taxa, etc.

Specimen citation(s). Cite the label data from the voucher specimen(s). Include location data (generalize for protected species if desired), collection data, *collector(s) collection number* (herbarium symbol—following *Index Herbariorum* whenever possible). Ecological notes and/or associated species can be added if desired.

Literature Cited. Prepare as for any submitted paper.

The name and address of the author(s) concludes the entry.

The Editorial Board

NOTEWORTHY COLLECTIONS

MICHIGAN

CERASTIUM GLOMERATUM Thuill. (Caryophyllaceae). Clammy Chickweed.

Previous knowledge. This species has been reported only once (see Voss 1985) before from Michigan (Washtenaw Co., *Reznicek 4952* in 1978, MICH, MSC). Other reports in the Great Lakes region: collections made in several counties west of Chicago, Illinois (Swink & Wilhelm, 1979). Schlising & Iltis (1962) discount Fassett's 1957 report of the species in Wisconsin. (Herbaria consulted: MICH, MSC).

Significance. These collections document the occurrence of *C. glomeratum* in a second county in Michigan. *Cerastium glomeratum* is a common plant in the southeastern United States and in the southern portions of Illinois (Mohlenbrock & Ladd, 1978), Indiana (Deam, 1940), and Ohio (specimens at OS), being only rarely reported at more northerly sites. Abundance of the plants (especially at site of *Rabeler 909*) suggests that it could be a locally common, but overlooked, plant in Michigan. The very early flowering date of these plants (the Reznicek collection was made on 21 June) could be influenced by heat introduced by steam pipes below the collection site.

INGHAM CO.: Lawn E of Eppley Center, S of road (off Bogue St.) to Eppley Center loading dock, near sidewalk along W side of Bogue St., Michigan State University campus, T4N, R1W, SW¹/₄ of Sec. 18, 29 April 1985, *Rabeler 861* (MICH); 3 May 1985, *Rabeler 863* (MSC); 9 May 1985, *Rabeler 865* (BLH, DAO, MICH, MSC). Plants abundant among *Stellaria media*, *Veronica* sp. in dry soil surrounding steam tunnel access grating, lawn S of Physics-Astronomy Building, Michigan State University campus, T4N, R1W, SW¹/₄ of Sec. 18, 2 May 1986, *Rabeler 909* (MICH, MSC).

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Schlising, R. A. & H. H. Iltis. 1962["1961"]. Preliminary reports on the flora of Wisconsin. No. 46. Caryophyllaceae. Trans. Wis. Acad. Sci. 50: 89-139.
Swink, F. & G. Wilhelm. 1979. Plants of the Chicago Region. The Morton Arboretum, Lisle, Illinois.
Voss, E. G. 1985. Michigan Flora, Part II. Bull. Cranbrook Inst. Sci. 59 and Univ. Michigan Herbarium. xix + 724 pp.

GYPSOPHILA MURALIS L. (Caryophyllaceae). Cushion Baby's Breath.

Previous knowledge. As I reported earlier (Rabeler, 1981), the only other Michigan specimens of *G. muralis* were collected in 1899 or 1900 in Ingham, Manistee, and Muskegon Counties. Other reports in the Great

Lakes region: collections made since 1960 have been seen from Summit County, Ohio and Marquette, Marathon, and Portage Counties, Wisconsin. It is not known from Lake County, Indiana contrary to Hull (1938) and Swink and Wilhelm (1979); Hull's collection is a misidentified specimen of *Gypsophila paniculata* (collection at GH). (Herbaria consulted: CAN, F, GH, ILL, MICH, MSC, NY, OS, UMO, UWSP, WIS.)

Significance. This is the first collection of *G. muralis* in Michigan in 86 years, confirming my 1981 suspicions of its existence "somewhere" in Michigan. It is also the first record of the species from the Upper Peninsula. The occurrence along a county road suggests that it is to be looked for elsewhere in the region.

GOGEBIC CO.: Along Co. Rd. 513, ca 1.5 mi N of Bessemer, T47N, R46W, center of Sec. 4, 12 Jul 1986, *Henson 2101* (MICH). Species collected at the same site: *Anthemis cotula* L., *Carex normalis* Mackenzie, *Trifolium arvense* L., and *Trifolium campestre* Schreber.

LITERATURE CITED

- Hull, E. D. 1938. New finds in the dunes. *Amer. Bot. (Binghamton)* 44: 161-162.
Rabeler, R. K. 1981. *Gypsophila muralis*. Is it naturalized in Michigan? *Michigan Bot.* 20: 21-26.
Swink, F. & G. Wilhelm. 1979. *Plants of the Chicago Region*. The Morton Arboretum, Lisle, Illinois.

-RICHARD K. RABELER, University of Michigan Herbarium, North University Building, Ann Arbor, MI 48109-1057.

REVIEW

ORCHIDS OF THE WESTERN GREAT LAKES REGION. By Frederick W. Case, Jr. Cranbrook Institute of Science Bulletin 48, Revised Edition. 1987. 251 pp. \$28.95; mail orders must include postage, handling (10% on orders between \$10.00 and \$50.01), and sales tax where applicable (500 Lone Pine Rd., P. O. Box 801, Bloomfield Hills, MI 48013).

Originally published in 1964, Fred Case's *Orchids of the Western Great Lakes Region* has been widely used and highly regarded by naturalists in the upper Midwest, and I know people who find uses for it far outside its intended geographical region. Books such as this, guides to special groups of wild plants, are usually written for the serious and somewhat experienced student of natural history, and they are frequently employed more as references than field guides. I have always considered this work to be "one of the good ones" among my collection of such books. Now, after 23 years, there is a new edition.

Physically, the new book isn't much larger than its predecessor. It has the same dimensions (6 1/4 by 9 1/4 inches) and is only slightly thicker (3/4 inch). However the new version contains over 100 additional pages of text and twelve more pages of plates. The paper is much glossier in the new edition, which I personally dislike (I find it much easier to read from flat rather than shiny pages, and coated papers are frequently less durable). Thirteen additional taxa are included, bringing the total to 65. This reflects both the discovery of new orchid taxa for the region and the implementation of new taxonomic treatments. The plates of the old edition included 58 photographs of orchids in their natural habitats, 42 of these in black-and-white. The new version has 83 photographs of orchid species, plus eight photographs of habitat types, all in full color. There is at least one close-up photograph of each taxon treated.

The book's introductory section covers, in an elementary but thorough treatment, the morphological specializations, reproductive biology, ecology, and phytogeography of orchids. The section on ecology has been expanded from nine to 24 pages, accommodating a more detailed examination of conditions that affect wild orchid populations and the need for preserving natural areas of the kind required by these plants for their survival. Twelve specific habitats are described in detail. Finally, directions are provided for the cultivation of various native orchids in the home garden.

The main section contains dichotomous keys to the genera and species, and for each species, a brief discussion and an outline map, divided into counties, with dots representing site records. The maps cover Michigan and Wisconsin, much of southern Ontario, and the adjacent parts of Minnesota, Illinois, Indiana, and Ohio. Strangely, the adjacent portions of northwestern Pennsylvania and western New York have been left blank, even though they lie no farther east than the part of Ontario to the north of Lake Erie, for which records are included. The keys, both to genera and species, are carefully constructed and work well for me. In both cases, the conventional dichotomous key is accompanied (in the margin) by line drawings, with small arrows highlighting important features. The author's style is clear, concise, and interesting, and his comments and suggestions demonstrate an intimate knowledge of each species, based on his many years of study of the family. The photographs, mostly taken by the author, are of excellent quality and should be of considerable use in identification.

Since the first edition, considerable study of the temperate New World orchids has been accomplished, and the accepted treatments of several of our species have changed. The taxonomic changes most evident include the transfer of all species of *Habenaria* to the genus *Platanthera*, the division of *Spiranthes cernua* into several separate species, and the transfer of *Orchis spectabilis* to the segregate genus *Galearis*. The work includes 14 taxa not included in the first edition, ten of these representing new records for the range of the book, and four representing taxa now segregated from other species. Where changes in nomenclature have occurred, clear cross-references are provided.

The book concludes with a good glossary, a selected bibliography (about twice the size of the one in the first edition), and (unfortunately) separate indexes (*à la* Gray's Manual) for the scientific and common names. The very few shortcomings of this book are extremely minor in comparison with its overall high quality and usefulness. As before, it is written primarily for the amateur (but somewhat knowledgeable) naturalist, but every botanist interested in the native plants of the Great Lakes region, whether amateur or professional, will want to own this excellent little volume. It is one of the good ones.

—John J. Furlow
Department of Botany
Ohio State University

PUBLICATIONS OF INTEREST: AQUATICS

Three recent and very different publications for identification of aquatic plants are briefly noted here. Each may be of interest to botanists who do not mind getting their feet wet (those who do should seek another line of work).

A FIELD GUIDE TO VALUABLE UNDERWATER AQUATIC PLANTS OF THE GREAT LAKES. By Donald W. Schloesser. Michigan State Univ. Coop. Ext. Serv. Ext. Bull. E-1902. 1986. 32 pp. \$3.50. This little pamphlet treats four macroscopic algae and 15 vascular plants (either genera or species). For each of these, the main feature is a pair of color photographs: a small one showing the overall aspect of the plant (in an aquarium) and another (usually larger than natural size) showing details—with such effective lighting that features of venation and stipules are usually remarkably clear. Only a small fraction of the submersed aquatics are covered, and the title may strike one as strange in referring to them as “valuable” when such aggressive exotic weeds as Eurasian water-milfoil and curly pondweed are included. But the original photography and color-coded indications of “value” (food, habitat, recreation interference, etc.) will make this helpful at least to beginners.

AQUATIC AND WETLAND PLANTS OF KENTUCKY. By Ernest O. Beal & John W. Thieret. Kentucky Nature Preserves Commission Sci. Tech. Ser. 5. 315 pp. 1987 [“1986”]. \$20.00 postpaid (407 Broadway, Frankfort, Kentucky 40601). In contrast to the preceding pamphlet, this volume aims to treat all submersed and emergent aquatic vascular plants of the state (over 400 spp.), even including a number of species likely to be found but not yet documented from Kentucky. There are full identification keys, habitat notes, county-distribution maps for the state, and line drawings. There is a very full and well done glossary (although the definition of “stipule” does not apply very clearly in *Potamogeton*). Families and genera are arranged in a single alphabetical sequence (as in the Slink & Wilhelm *Plants of the Chicago Region*). The illustrations, by Sara Fish Brown, are mostly quite good although some are a little on the stiff or formalized side. Instructions on how to interpret and use the book are clear, concise, and helpful. The work was evidently languishing three or four years in press, after Thieret finished the manuscript following Beal's death in 1980. Consequently, bibliographic references and some other points are occasionally “dated.” *Nuphar lutea* ssp. *macrophylla* should be ssp. *advena*. But in general, nomenclature and taxonomy are timely.

PLANTES SAUVAGES DES LACS, RIVIÈRES ET TOURBIÈRES. Fleurbec auteur et éditeur. 399 pp. 1987. \$24.95 Can. (Saint-Augustin, Québec, Canada G3A 1W8). This is a beautiful little book, illustrated with over 150 color photos, most of them extraordinarily good, designed for identification of aquatic and bog plants in Québec. The organization is by habitat, and to some extent flower color, but there are no keys. However, the superb pictures are usually enough for identification. The text includes descriptions as well as information on habitat, folklore, horticultural or agricultural matters, edibility, toxicity, and reputed medicinal uses. There are 36 pages devoted to floristic regions of North America and the various kinds of wetlands. Distribution maps for 65 species strain so hard to avoid errors of commission that the results are sometimes startling, excluding from Michigan, for example, a number of species (such as *Mimulus ringens*, *Kalmia* spp., *Chamaedaphne*, *Ledum*, *Lysimachia terrestris*, *Utricularia cornuta*) found throughout the state (but not in *Michigan Flora* Parts I and II!). More effort to determine distributions would have improved the maps. Scientific names are given for each species, but the discussion uses mainly French common names and the text is entirely in French. Those for whom this language is no problem, including those who would simply like good pictures of many aquatic and bog species, will enjoy this book. (In the absence of instructions regarding postage, converting from Canadian dollars, bank charges, etc., I sent a check for \$20.00 US to Fleurbec and received a copy promptly.)

PUBLICATION OF INTEREST

CONIFERS. Keith D. Rushford. 1987. Facts on File, Inc., New York. 232 pp. 20 color plates. 31 figures. \$24.95 hardcover. Conifers are an important part of many ecosystems of the world. They are the source of much of the timber and pulp used in commerce and are used extensively in landscaping. The forms and textures of the various species range from ground covers (*Juniperus horizontalis*, creeping juniper) to the tallest trees (*Sequoia sempervirens*, coastal redwood). Various conifers can be found in deserts, rainforests, tropical forests, and boreal forests. They are truly a diverse group. Any book which essays to cover all aspects of the phytogeography, life history, ecology, and taxonomy of conifers is attempting a herculean task. *Conifers* does not strive for such all-inclusiveness, but concentrates on the use of conifers in landscaping and gardening. A chapter on the biology of conifers provides a thumbnail sketch of classification, cone production ("Flowers and Fruits"), seed dispersal, and the major organs (branches, leaves, stem, roots) of the plant. This chapter should only be used as an introduction and not a main source on these subjects. Other chapters present information on use of conifers in the garden, dwarf species and cultivars, propagation, planting, and pests and diseases. The major part of the book is a gazetteer of nearly 600 species. In most cases each entry contains a description of the plant (including size, branching and bark characteristics, leaf form and size, etc.) and a brief discussion of its native habitat and usefulness in landscaping. While the line drawings and plates are useful in identifying some species, most species are not illustrated. No keys are provided so the reader must know at least the genus to find the appropriate information. Both scientific and English names are given for each species. Some of the English names will not be familiar to many in the United States but will likely be known to readers in Canada (e.g., Weymouth pine instead of white pine for *Pinus strobus*). At the end of the book are two appendices giving hardiness zones for Europe and North America and conversion tables between metric and imperial measures, a short bibliography, glossary, and indices to scientific and English names. This book would be useful to those interested in growing conifers in gardens and to amateur botanists wanting an introduction to the variety of conifers. It would not be a substitute for a good field guide, especially since no keys to species are given.

-James A. Weber

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THE SEED BANK AND ABOVE-GROUND VEGETATION IN AN UPLAND PINE-HARDWOOD SUCCESSION

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An important, but often overlooked, component of terrestrial plant communities is the seed bank. For example, a major source of recruitment into communities following disturbance is from buried seeds and subsequent successional trajectories can be influenced by which species establish first in a site (Harper 1977). Seed banks can have significant effects on population structure and dynamics (Cavers 1983). For some annual species the majority of an individual's life may be spent as a seed in the soil (Harper 1977). The dynamics of some populations have been shown to be influenced by input into and germination from the seed bank (Sarukhan 1974, van Baalen & Prins 1983, Wertis & Ungar 1986, Scheiner 1988). Recruitment from a seed bank also can influence the genetic structure of populations (Templeton & Levin 1979). Scheiner & Teeri (1987) found a significant change in the genetic composition of a population of the grass *Danthonia spicata* in one year following clear-cutting and fire in a pine-hardwood forest in northern lower Michigan. The change was not due to natural selection but rather new individuals arising from the seed bank. Thus it is important to determine which species are present in the seed bank as a first step in determining its importance in population and community structure.

I report here on a survey of the seed bank of an upland pine-hardwood succession sequence in northern lower Michigan. A comparison is made between the species composition of the seed bank and the above-ground vegetation. In particular, the seed bank and vegetation on one site was surveyed for three years following clear-cutting and fire. Thus, this study provides some understanding of the sources for recruitment into this newly disturbed site. This successional sequence is of special importance because it is one of the longest studied with an extensive longitudinal data base. This report updates and expands on previous studies (Scheiner & Teeri 1981, Cooper 1981).

METHODS

The sites are a set of experimental and natural burns at the University of Michigan Biological Station in northern lower Michigan (45°34' N lat., 84°42' W long., 237 m elev.). Mean annual precipitation is about 800 mm, distributed evenly throughout the year. The frost-free period averages about 90 days (Anonymous 1971). The soil is a sandy, mixed frigid Entic Haplorthod of the Rubicon series, derived from glacial outwash (Unpubl. USDA-SCS Map 1976, Grayling, Mich.). The area supports a second-growth pine-hardwood stand which originated following logging in the late nineteenth century and a wildfire in 1911. The vegetation is in transition from predominantly *Populus grandidentata* (bigtooth aspen) to *Pinus strobus*

(white pine), *P. resinosa* (red pine), *Quercus rubra* (northern red oak), and *Acer rubrum* (red maple). The experimental burns were done in 1936, 1948, 1954, and 1980, respectively. The fifth site was burned by a wildfire in 1911.

The following is a description of the procedure used in the 1980 burn which was designed to be as similar as possible to earlier experimental burns. Within the study area, a site measuring 120 m \times 100 m was clear-cut in the fall of 1979 and the early spring of 1980. After the logs were removed, the slash was piled to dry. The site was burned on Aug. 19, 1980. The fire was patchy and approximately 15% of the site remained unburned. For additional site descriptions see Scheiner & Teeri (1981, 1986) and Cooper (1981).

Samples of the seed bank in the five sites were collected in three consecutive years, in 1980 on Aug. 18 (the 1954, 1948, 1936, and 1911 sites) and Aug. 22 (the 1980 site), in 1981 on Aug. 7 and Aug. 8, and in 1982 on Aug. 2 to Aug. 5. Twenty liters of soil were collected from each site in each year as either 20, in 1980, or 34, in 1981 and 1982, samples from each site. Sampling depth was 12 cm. All samples were taken along a set of five parallel N-S transects five meters apart with 3 m separating each sample point. The placement of the first transect was random. The soil was placed in paper bags, air dried, stored at room temperature, sifted to remove all twigs, roots, and stones, and mixed. Ten liters of soil from each site was placed in two trays, five liters per tray, in the University of Chicago greenhouse on Dec. 10, 1980, Nov. 18, 1981, and Sept. 22, 1982, respectively. The 10 liters of soil represents a surface area of 0.0833 m² per site for a total area of 0.25 m² sampled per site over the three years. The trays were watered daily, fertilized once a week, and stirred occasionally. Seedlings were counted every two weeks and identified to species when possible until no additional germination was observed for a period of eight weeks. Nomenclature follows Voss (1972) for gymnosperms and monocots and Gleason and Cronquist (1963) for other taxa.

The frequency of vascular plant species in each site was determined by surveying 100 1 \times 1 m² quadrats laid out along a set of five parallel N-S transects five meters apart with three meters separating each sample point. The placement of the first transect was random. The presence of all species within each quadrat was recorded. Frequency is the percentage of quadrats in which a species appeared. All five sites were sampled in 1981 on July 22 to July 25. Additionally, the 1980 burn site was sampled on July 27, 1982 and July 14, 1983. Diversity was measured using the inverse Simpson's index (Peet 1974). See Scheiner & Teeri (1981) for further details on methods.

RESULTS AND DISCUSSION

The results of the seed bank sampling are shown in Table 1. There were no significant differences among samples taken in the three years so the pooled totals are shown. A total of 969 seeds from 23 species germinated ranging from a high of 300 seeds from 15 species in the 1954 burn site and a low of 98 seeds from 5 species in the 1980 burn site. Each germinating seed represents 4 seeds per m² in the soil giving a range of seed densities of 392 to 1200 seeds per m². The methods used here may underestimate the actual seed bank density because of ungerminated but viable seeds (e.g. Archibold 1979, Abrams & Dickman 1984) so these are minimal estimates. However, Moore and Wein (1977) working in similar forests found no ungerminated but viable seeds suggesting that the underestimate in the present case may not be too severe.

Despite variation among sites the relative rankings of seed abundances of the 10 most common species did not differ among sites (Kendall's coefficient of concordance $W = 0.50$, $P < 0.01$; Seigel 1956, p. 229). By far the most common species was *Carex rugosperma* accounting for 40% of all

Table 1. Total number of seedlings germinating from soil samples collected in 1980, 1981, and 1982 from 5 sites of different ages since fire. Sites are named by the year of the last disturbance.

Species	Life-form*	Site				
		1980	1954	1948	1936	1911
<i>Agrostis hyemalis</i>	G	0	39	41	15	14
<i>Arenaria serpyllifolia</i>	A	65	1	2	0	31
<i>Betula papyrifera</i>	T	0	0	1	2	2
<i>Carex rugosperma</i>	G	28	134	56	104	66
<i>Cirsium</i> sp.	B	0	0	0	1	0
<i>Danthonia spicata</i>	G	0	10	12	3	1
<i>Diervilla lonicera</i>	S	0	0	4	0	1
<i>Erigeron canadensis</i>	A	0	1	0	0	0
<i>Gnaphalium obtusifolium</i>	A	0	2	2	0	0
<i>Hieracium</i> sp.	P	0	2	2	0	0
<i>Hypericum perforatum</i>	P	0	0	5	0	0
<i>Krigia virginica</i>	A	0	0	1	0	0
<i>Oryzopsis asperifolium</i>	G	0	22	2	19	5
<i>Panicum columbianum</i>	G	0	20	32	1	0
<i>Panicum depauperatum</i>	G	0	9	35	0	0
<i>Poa compressa</i>	G	1	5	1	3	0
<i>Rubus</i> sp.	P	0	0	0	0	1
<i>Solidago hispida</i>	P	0	8	9	4	0
<i>Verbascum thapsus</i>	B	0	1	0	0	0
Unknown dicot 1		0	0	0	1	0
Unknown dicot 2		0	0	0	1	0
Unknown dicot 3		0	1	0	0	0
Unknown dicot 4		2	2	0	0	1
Total no. of seeds		98	300	223	205	143
Total no. of species		5	15	15	12	10
No. of graminoid seeds		29	239	179	145	86
No. of annual seeds		67	47	23	51	52

*A = Annual, B = Biennial, G = Graminoid,
P = Herbaceous perennial, S = Shrub, T = Tree

seeds. Graminoids constituted between 60% and 80% of the seeds in the 1954, 1948, 1936, and 1911 burn sites but only 30% in the 1980 burn site. The majority of the remaining seeds were made up by two annual species, *Gnaphalium obtusifolium* and *Arenaria serpyllifolia*. Seeds from only one tree species, *Betula papyrifera*, were found and no large seeds such as acorns were discovered during soil sifting. One species notable by its absence was *Aralia hispida*. Large numbers of seedlings were seen in the 1980 burn site nine days following the fire (pers. obs.) but it was not recorded in the seed bank survey.

The density of seeds in the soil of this upland pine-hardwood successional sere was similar to those of other temperate mixed conifer-hardwood

forests (Livingston & Allesio 1968, Moore & Wein 1977, Archibold 1979). Abrams & Dickman (1984) sampled the seed bank of a jack pine successional sere in Ogemaw county in northern lower Michigan. They found seed densities ranging from 37 to 1202 seeds per m² from a total of 15 species including many of the same genera and species identified in this study.

The results of the vegetation sampling are shown in Table 2. The general successional trends were similar to those reported in earlier studies (Scheiner & Teeri 1981, Cooper 1981). *Populus grandidentata* was the most common tree in the youngest site. In progressively older sites it declined in frequency while *Pinus strobus*, *Acer rubrum*, and *Quercus rubra* increased. The understory was dominated by *Pteridium aquilinum* and *Carex rugosperma* in the 1980 burn site. Other herbaceous species which increased in frequency in the years immediately following fire were *Danthonia spicata*, *Hieracium piloselloides*, *Panicum columbianum*, and *P. depauperatum*. *Vaccinium angustifolium* was common in all of the sites. *Erigeron canadensis*, an annual, showed a pattern of abundance typical of many early successional species. It was common in the year immediately following fire. During the second summer its frequency tripled but then it virtually disappeared the next year. It was not found at all in any of the older sites. In contrast, the perennials *Poa compressa* and *Solidago hispida* although present immediately after fire were commonly found only in the older sites. There was no pattern through time in total number of species but diversity showed a peak in intermediate aged sites. The decline in diversity in the 1911 burn site was due to a reduction in the number of herbaceous perennials many of which were confined to a few canopy gaps (Scheiner & Teeri (1986). This observation is contrary to those of Scheiner & Teeri (1981) who found no decline in diversity during the first 53 years of secondary succession.

There was little relationship between the species composition of the seed bank and the above-ground vegetation. The only species which was in high abundance in both surveys was *Carex rugosperma*. All species found in the seed bank were present in the above-ground vegetation although not always in the same site. For example, large numbers of seeds of *Arenaria serpyllifolia* were found in the soil from the 1911 burn site although it had been found growing only in the 1980 burn site. Similarly, *Gnaphalium obtusifolium* was abundant in the seed bank but rare or absent above-ground. Spearman rank correlations (Seigel 1956, p. 202) of numbers of seedlings and frequencies of above-ground vegetation of the common seed bank species failed to find significant correlations for any of the five sites ($r_s = 0.11 - 0.41$, $n = 9$, N.S.). A lack of concordance between the above-ground vegetation and the seed bank has been found in other studies (Oosting & Humphreys 1940, Champness & Morris 1948, Major & Pyott 1966, Livingston & Allesio 1968, Thompson & Grime 1979, Archibold 1979, Vlahos & Bell 1986).

From the information presented here on the seed bank and patterns of species abundance preliminary conclusions about the importance of various modes of recruitment can be made. A separate study of patterns of recruitment in the three years following fire was done in the 1980 burn site

Table 2. Frequency of vascular plant species in the 5 sites based on 100 1 × 1 m² quadrats. All sites were surveyed in 1981. The 1980 burn site was also surveyed in 1982 and 1983.

Species	Site						
	1980		1954	1948	1936	1911	
	Years since fire						
	1	2	3	27	33	45	70
Acer rubrum	2	2	2	30	48	31	67
Agrostis hyemalis	4	3	6	P*	4	1	P
Amelanchier arborea	3	P	P	18	44	33	26
Antennaria plantaginifolia	P	P	0	P	1	P	P
Apocynum androsaemifolium	0	0	0	1	0	0	0
Aralia hispida	P	P	P	0	0	0	0
Arenaria serpyllifolia	P	P	0	0	0	0	0
Asclepias syriaca	0	0	0	P	1	P	0
Aster laevis	P	P	0	1	1	P	P
Betula papyrifera	2	1	P	P	1	P	P
Carex aenea	P	P	1	0	0	0	0
Carex rugosperma	94	93	93	42	24	45	2
Centaurea maculosa	P	P	P	0	0	0	0
Cirsium palustre	0	P	0	0	0	0	0
Comandra umbellata	P	0	0	0	4	0	P
Convolvulus spithameus	P	0	P	18	3	P	0
Cypripedium acaule	P	0	0	P	P	P	P
Danthonia spicata	3	19	8	40	31	26	P
Diervilla lonicera	P	P	P	P	1	3	2
Epigaea repens	P	P	P	P	P	P	P
Erigeron canadensis	16	48	P	0	0	0	0
Erigeron strigosus	0	0	0	0	0	P	0
Fagus grandifolia	0	0	0	0	P	1	3
Fragaria virginiana	P	1	0	0	0	0	0
Gaultheria procumbens	1	P	P	11	9	P	64
Gaylussacia baccata	5	7	10	13	P	P	P
Gnaphalium obtusifolium	P	3	0	P	1	0	P
Gymnocarpium dryopteris	0	0	0	0	0	0	P
Helianthemum canadense	0	0	0	0	0	P	0
Hieracium aurantiacum	P	P	P	P	0	0	0
Hieracium piloselloides	8	20	16	66	40	32	P
Hieracium scabrum	0	0	0	0	P	P	P
Hieracium venosum	P	1	0	7	6	12	1
Hypericum perforatum	P	P	0	P	1	0	0
Krigia virginica	0	0	0	P	P	0	0
Lycopodium complanatum	0	0	0	0	0	0	P
Maianthemum canadense	0	0	0	0	0	0	P
Melampyrum lineare	P	P	1	1	10	P	4
Lactuca canadensis	0	P	0	0	P	0	0
Monotropa hypopithys	0	0	0	2	4	5	5
Monotropa uniflora	0	0	0	0	0	1	2
Oenothera biennis	P	P	0	0	0	0	0
Oryzopsis asperifolia	P	P	P	2	P	2	1
Oryzopsis pungens	3	P	2	50	9	16	P

(continued)

Table 2. (continued)

Species	Site						
	1980			1954	1948	1936	1911
	Years since fire						
	1	2	3	27	33	45	70
<i>Panicum</i> sp.**	5	21	17	35	35	5	0
<i>Panicum columbianum</i>	P	P	P	P	P	P	P
<i>Panicum depauperatum</i>	P	P	P	P	P	P	P
<i>Panicum xanthophysum</i>	0	0	0	0	P	P	0
<i>Pedicularis canadensis</i>	0	0	0	0	P	0	0
<i>Phleum pratense</i>	P	P	0	0	0	0	0
<i>Pinus banksiana</i>	0	0	0	P	0	P	0
<i>Pinus resinosa</i>	0	0	0	P	P	P	3
<i>Pinus strobus</i>	P	P	P	1	4	9	4
<i>Poa compressa</i>	P	1	2	16	11	44	P
<i>Poa pratensis</i>	P	P	1	0	0	0	0
<i>Populus grandidentata</i>	61	64	51	31	41	18	5
<i>Populus tremuloides</i>	P	6	3	0	0	0	P
<i>Prunus pensylvanica</i>	1	4	2	P	0	0	0
<i>Prunus serotina</i>	0	0	0	0	0	P	0
<i>Pteridium aquilinum</i>	97	99	96	96	98	98	99
<i>Pyrola virens</i>	0	0	0	P	P	0	P
<i>Quercus rubra</i>	1	4	5	15	10	13	9
<i>Rhus typhina</i>	0	0	0	P	P	0	0
<i>Rubus allegheniensis</i>	4	P	P	0	0	0	0
<i>Rudbeckia hirta</i>	0	P	P	0	0	0	0
<i>Rumex acetosella</i>	P	0	0	0	0	0	0
<i>Salix humilis</i>	0	0	0	P	P	P	0
<i>Scutellaria elliptica</i>	0	0	P	0	0	0	0
<i>Silene antirrhina</i>	0	0	0	0	1	0	P
<i>Smilicina racemosa</i>	P	P	0	0	P	1	0
<i>Solidago hispida</i>	P	P	P	60	52	42	P
<i>Solidago juncea</i>	0	P	P	16	9	8	P
<i>Solidago rugosa</i>	0	P	P	0	0	0	0
<i>Spiranthes lacera</i>	0	0	0	0	P	0	0
<i>Taraxacum</i> sp.	P	0	P	0	0	0	0
<i>Tragopogon dubius</i>	P	0	0	0	0	0	0
<i>Trientalis borealis</i>	0	0	0	0	0	0	P
<i>Tsuga canadensis</i>	0	0	0	0	P	0	0
<i>Vaccinium angustifolium</i>	29	24	32	26	50	24	70
<i>Vaccinium myrtilloides</i>	P	P	P	P	0	0	3
<i>Verbascum thapsus</i>	P	P	P	0	0	0	P
<i>Veronica</i> sp.	P	0	0	0	0	0	0
<i>Viburnum acerifolium</i>	P	P	P	0	0	0	0
Total no. of species	51	50	41	42	48	42	44
Diversity	4.03	6.64	5.45	11.79	11.23	9.84	4.98

*P = Present

**Unable to distinguish species as seedlings.

(Scheiner et al. 1988). The dominant tree species following fire, *Populus grandidentata*, was recruited exclusively from root sprouts. *Acer rubrum* was recruited only from stump sprouts. *Amelanchier arborea*, *Betula papyrifera*, and *Quercus rubra* were recruited both vegetatively and by seed while *Prunus pensylvanica* was recruited exclusively by seed. *Betula papyrifera* was the only tree species found in the seed bank survey. As with the trees, the dominant understory species, *Pteridium aquilinum*, was recruited exclusively from rhizome resprouts. The shrubs *Gaylussacia baccata* and *Vaccinium angustifolium* also resprouted from roots the year following fire (pers. obs.) although later increases in frequency may have included recruitment by seed.

Of the herbaceous species which increased in frequency following fire two patterns can be seen. The graminoid species, *Carex rugosperma*, *Danthonia spicata*, *Panicum columbianum* and *P. depauperatum*, showed substantial seed banks in at least some of the sites. In contrast the two species in the Asteraceae, *Erigeron canadensis* and *Hieracium piloselloides*, had virtually no seed bank. The first set of species all have seeds which are passively dispersed close to the adult plant (pers. obs.) while the other two species have light, wind dispersed seeds that likely migrated into the 1980 burn site following the fire.

SUMMARY

A survey was made of the seed bank and above-ground vegetation of five sites in a 70 year upland pine-hardwood successional sere in northern lower Michigan. Total seed densities ranged from 392 to 1200 seeds per m² from a total of 23 species. *Carex rugosperma* accounted for 40% of the seeds. There were no significant differences in the species relative seed densities in the five sites. *Populus grandidentata* was the most common tree species during earlier succession giving way to *Pinus strobus*, *Quercus rubra*, and *Acer rubrum* in later years. Total species diversity was greatest in intermediate aged sites. Little concordance was found between the seed bank and above-ground vegetation except that *Carex rugosperma* was frequent in both. Following fire trees and shrubs were recruited primarily from root and stump sprouts. Graminoid species were apparently recruited from the seed bank. Two species in the Asteraceae were rare in the seed bank and appeared to have dispersed into the site.

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A NOTE ON NURSE TREES AND BROWSING

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"Nurse tree" is defined in Webster's Third New International Dictionary as "a tree that protects or fosters the growth of other young trees". A similar principal is involved in the agricultural use of "nurse crops" (see also in Webster's), as in the common practice of seeding alfalfa or clover, slow-starting perennial legumes, with an annual grain such as oats, which provides shade and protection from wind for the more delicate legume seedlings. In general, nurse plants may serve to improve the microhabitat for the dependent species in various ways, e.g. protection from sun and wind and temperature extremes (Braun-Blanquet 1932), soil amelioration (Whitford & Whitford 1978), and, perhaps more obviously, protection from browsing and grazing (Braun-Blanquet 1932). Saguaro cactus seedlings were found to have high mortality from dessication and from herbivores except where protected by nurse plants or by rocks (Steenbergh & Lowe 1969); they stated that "the number of species observed as 'nurse plants' suggests that association with other plants is not linked to any particular species, but rather to certain structural characteristics of the associated plants". Braun-Blanquet (1932) stressed the protective role of spiny shrubs in grazed lands, including examples of both *Crataegus* and *Juniperus* as nurse plants.

We have observed an apparent case of nurse trees protecting another species from grazing and browsing. The site is a small permanent pasture about 3 km SE of the village of Green Lake in central Wisconsin. It lies about mid-slope on the Galena-Black River escarpment (Martin 1932) on a steep (est. 35-40°) north-facing slope of shallow soil over dolomitic limestone, with some exposed bedrock ledges, loose stones and boulders. The effects of many years of intense grazing and browsing by both domestic cows and native white-tailed deer is evident in the very short (≤ 5 cm) ground cover of bluegrass and grazing-tolerant weeds, and also in the sparsity of larger, woody perennials.

We first observed the site in late May of 1987 when the shape of the tree clumps as seen from the road caught our attention. Closer observation revealed eight buckthorn trees (*Rhamnus cathartica*) about 4-5 m tall, each growing up through bushy red cedars (*Juniperus virginiana*). These are grouped, along with one lone red cedar 6 1/2-7 m tall, in a mid-slope area of perhaps 100 × 120 m with open short pasture sod on three sides and a road

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Figure 1. Browsed buckthorn-red cedar clumps, Jan. 1988

fence on the fourth side (see Figs. 1,2). All of these buckthorns have been repeatedly browsed on all branches < 1.3 m above the ground, so that remaining branches at this level are very short and densely branched. Near the middle of each clump, protected in part by the junipers, the topmost bud or buds of the buckthorn eventually grew above the reach of deer and cows and spread into normal crowns.

Rechecking on January 12, 1988, with about 5 cm of snow cover on the ground, showed numerous deer tracks and droppings around the clumps and recently chewed twigs of both species. Apparently only the youngest tips of the cedar are used and the buckthorn seedlings were able to get started within the dense older growth of the cedars after the latter had reached $1-1\frac{1}{2}$ m in height. Now the buckthorns are outgrowing the cedars and obviously overtop them.

We had not seen this combination of species in such a relationship before, nor read of its occurrence. In fact, while red cedar is commonly browsed to some degree (Martin, Zim & Nelson 1951), even to a typical "hour-glass" shape or nearly bare trunk (Watts 1975), we were surprised to find the buckthorn apparently more palatable to deer and/or cattle. The distribution of the cedars indicates that they started in crevices or against boulders, giving them some protection until they hardened enough to survive. Curtis (1959) indicates that such rocky slopes are a common habitat of red cedar, where the rocks may have protected them from fire as well as from browsing.

Buckthorn is an introduced Eurasian species, now widespread in south-



Figure 2. Closer view of largest buckthorn with cedar and boulders, Jan. 1988

ern Wisconsin, where it is spread mainly by birds which feed on the berries (Martin, Zim & Nelson 1951). It is common in fence rows and in disturbed forest and wooded borders, and is often considered a nuisance. On this site no buckthorns were found in the pasture except those protected by cedars (and two specimens of about $1\frac{1}{2}$ m protected against rocks and now severely browsed and greatly suppressed), indicating that the cedar "nurse trees" were essential to establishment of buckthorn under the browsing and grazing regime at this site. A close search of the area in April, 1988, revealed no trace of other buckthorns even under other trees (oaks, one elm, and one

cottonwood) around the edges of the open pasture. An old pasture site about 10 km distant but ungrazed for ≥ 10 years and with less deer usage does contain scattered buckthorns up to $1\frac{1}{2}$ m tall, proving a) that no perch trees are needed for dispersal in open pasture and b) that dense ungrazed bluegrass sod does not prevent ecesis of buckthorn.

The role of nurse plants evidently has become unfashionable as a research topic; neither *Ecology* indices nor *Bioresearch Index* lists anything under "nurse tree" or "nurse plant" since 1969, yet such interactions could play an important role in vegetation management. Further studies on the role of nurse plants might, for example, utilize exclosure plots, particularly within larger exclosure plots where the intensity of browsing could be controlled. Use of browsing pressure to control nuisance buckthorn or other invaders in managing semi-natural areas might be possible, but we foresee problems in such an approach, first in providing and controlling the browsing/grazing intensity and second, in preventing damage to associated desirable native plants. Possibly a properly-timed brief period of controlled animal use would control *Rhamnus* invasion in early stages (< 1 m high), or control resprouting after cutting, but careful experiments would be needed to determine timing and intensity relative to effectiveness and to monitor damage to more desirable species. We expect that, on the whole, hand cutting and spot use of chemicals would be simpler, safer and more cost-effective.

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LICHENS OF SLEEPING BEAR DUNES NATIONAL LAKESHORE

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Sleeping Bear Dunes National Lakeshore is located along the eastern shore of northern Lake Michigan west of Traverse City. The park is comprised of three separate areas along the Lake Michigan shore and also North Manitou and South Manitou Islands. The mainland sections of the park include the shore and dunes and extends back inland to hardwood forests and abandoned farmlands. The shore and foredunes extend from the lake level up to over 450 feet (137m) above the lake at Sleeping Bear Dune. These active foredune areas have moving sand and typical vascular plants of active dunes. Behind the foredunes and on the secondary dunes there is less sand movement and the vegetation is of scattered balsam poplar (*Populus balsamifera*), juniper (*Juniperus communis* and *Juniperus horizontalis*), various shrub cherries (*Prunus* spp.) and jack pines (*Pinus banksiana*). On the older undisturbed dunes a mixed hardwood forest is developed with sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), basswood (*Tilia americana*), and beech (*Fagus grandifolia*) producing very shady forests.

Along some of the streams and smaller lakes there are bogs with black ash (*Fraxinus nigra*), white cedar (*Thuja occidentalis*) and willows (*Salix* spp.). There are numerous abandoned farms, orchards and gravel pits with open vegetational aspect throughout the park.

As part of my studies on the lichens and air quality in various National Parks, in 1987 I began a study of the lichens of Sleeping Bear Dunes. The only previous report of lichens from the park was by Armentano, et al. (1985) where they listed 23 species. Harris (1978) published keys for the lichens of the five counties immediately bordering the Mackinac Straits and noted some species from a wider area but the locality information in his keys is not precise for comparison with Sleeping Bear Dunes. There may be a few scattered collections in the Michigan herbaria but I have made no attempt to locate them.

Field work was done during June and July, 1987 when 847 collections were made at 27 localities. No collections were made on North Manitou Island but three localities were visited on South Manitou Island. A complete list of collection localities is given in the locality list at the end and are indicated on Fig. 1. Localities for collecting were selected first to give a general coverage of the park, second, to sample all vegetational types, and third, to be in localities that should be rich in lichens. Disturbed as well as undisturbed areas were studied. At each locality voucher specimens of all species found were collected. Identifications were carried out at the Univer-

sity of Minnesota where all specimens were deposited and a representative set of duplicates has been sent to the park. Label data for all specimens deposited at the University of Minnesota have been entered into the herbarium computerized data base.

LICHEN FLORA

The following list includes the 180 taxa found in the park at the 27 localities. Some of the segregate genera recognized by Egan (1987) in the fifth lichen checklist are not accepted here. There are four additional unidentified species, some of which are probably undescribed. The species reported by Armentano et al. (1985) but not found by me are enclosed in brackets. Species found only once are indicated by "Rare." Each species is followed by the locality number where it was found unless it was found at more than 6 localities, and then it is called "Common" followed by the number of different localities where it was found.

- Acarospora fuscata* (Nyl.) Arn. 18, 27
[*Anaptychia palmulata* (Michx.) Vain. (Armentano et al. 1985)]
Anaptychia setifera Räs. (Armentano et al. 1985) 12, 17, 20
Anisomeridium biforme (Borr.) R. Harris 2, 17
Anisomeridium nyssaegenum (Ell. & Ev.) R. Harris Rare 1
Arthonia caesia (Flot.) Körb. 3, 5, 8
Arthonia fuliginosa (Schaer.) Flot. Rare 14.
This is a new record for North America.
There are also specimens in MIN from Minnesota, Michigan (Pictured Rocks and Isle Royale) and Ontario (Slate Islands).
The thallus is whitish gray, ascocarps pinkish with bluish pruina, epithecium K+ aeruginose (compared with Lojka, Lich. Univ. # 143 and the species confirmed by R. Harris). *A. byssacea* also has a whitish thallus but the ascocarps have dense white pruina and the epithecium is K-.
Arthonia radiata (Pers.) Ach. 2, 5, 17, 24, 26
Arthothelium spectabile Flot. ex Mass. Rare 26
Bacidia bagliettoana (Mass. & De Not.) Jatta Rare 1
Bacidia circumspecta (Nyl. ex Vain.) Malm Rare 17
Bacidia naegeli (Hepp) Zahlbr. Rare 22
Bacidia schweinitzii (Tuck.) Schneid. 2, 8
Bacidia suffusa (Fr.) Schneid. Rare 17
Bryoria furcellata (Fr.) Brodo & Hawksw. Rare 21
Buellia arnoldii Serv. 6, 21, 23
Buellia punctata (Hoffm.) Mass. 1, 3, 4, 9, 20
Buellia schaeferi De Not. 4, 13, 21
Buellia stillingiana Steiner 5, 20, 22, 24
Calcium abietinum Pers. Rare 4
Calcium trabinellum (Ach.) Ach. Rare 4
Caloplaca cerina (Ehrh. ex Hedw.) Th. Fr. 2, 5, 9, 22, 25
Caloplaca chrysophthalma Degel. 1, 16, 17
Caloplaca flavorubescens (Huds.) Laund. 9, 17, 25
Caloplaca holocarpa (Hoffm.) Wade Common, 8 loc.
Caloplaca pollinii (Mass.) Jatta Rare 12
Candelaria concolor (Dicks.) B. Stein (Armentano et al. 1985) Common, 9 loc.
Candelaria fibrosa (Fr.) Müll. Arg. 9, 13, 25
Candelariella efflorescens R. Harris & Buck Common, 14 loc.
Candelariella vitellina (Hoffm.) Müll. Arg. Rare 18
Catillaria nigroclavata (Nyl.) Schuler 9, 16
Catinaria laureri (Hepp ex Th. Fr.) Degel. Rare 2
Cetraria arenaria Kärnef. 12, 20, 21, 23
Cetraria fendleri (Nyl.) Tuck. 2, 4
Cetraria halei W. & C. Culb. Common, 7 loc.
Cetraria orbata (Nyl.) Fink Rare 21
Cetraria pinastri (Scop.) Gray Rare 4
Chaenotheca ferruginea (Turn. ex. Sm.) Mig. Rare 6
Chaenothecopsis savonica (Räs.) Tibell Rare 6

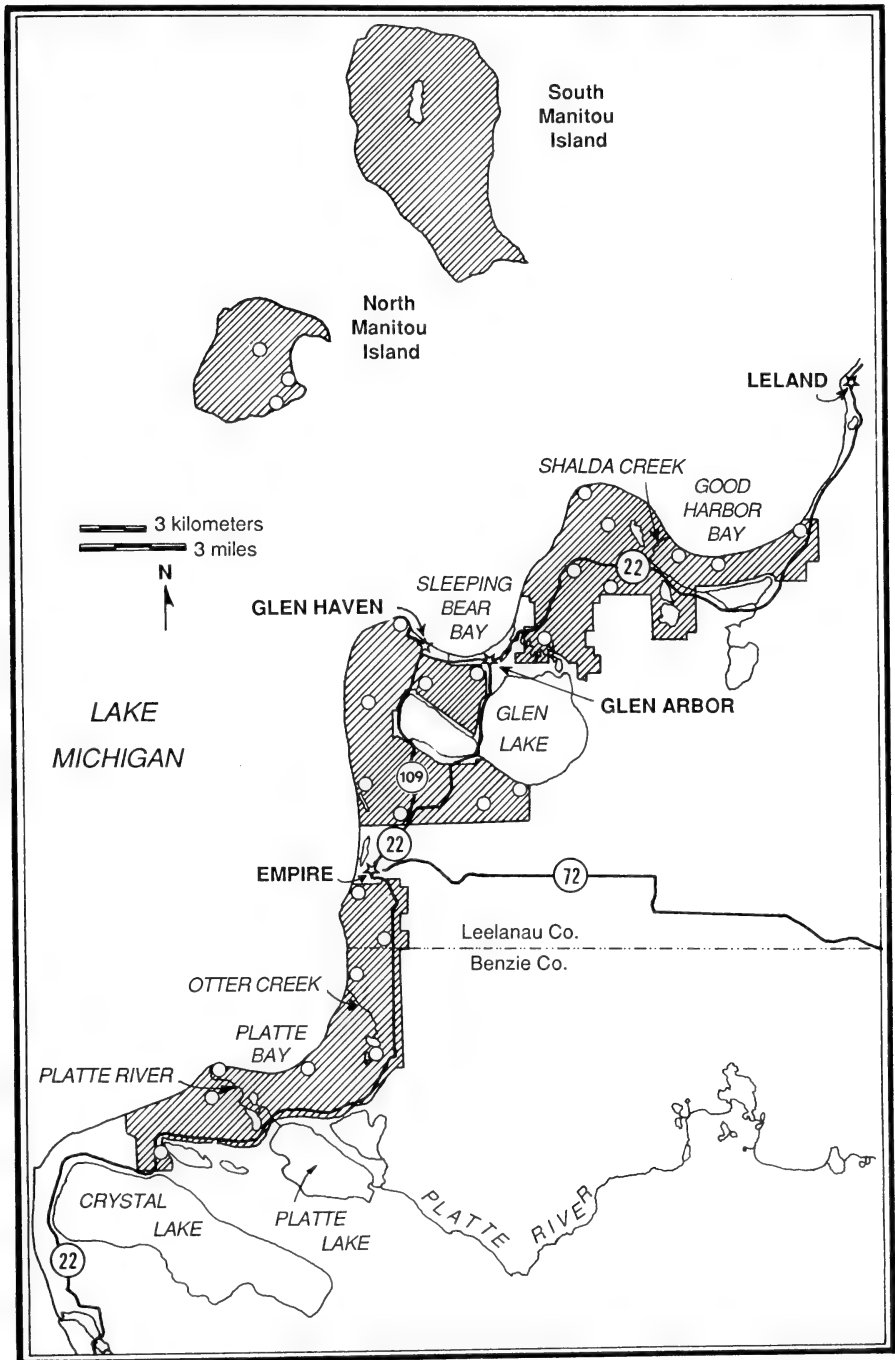


Fig. 1. Sleeping Bear Dunes National Lakeshore showing collection localities. Open circles are localities where complete collections were made.

- Cladina mitis* (Sandst.) Hustich Common, 14 loc.
- Cladina rangiferina* (L.) Nyl. Common, 13 loc.
- Cladina stellaris* (Opiz) Brodo 4, 24
- Cladonia acuminata* (Ach.) Norrl. 1, 15, 20, 21, 23
- Cladonia bacillaris* Nyl. Common, 6 loc.
- Cladonia bacilliformis* (Nyl.) Glück Rare 5
- Cladonia caespiticia* (Pers.) Flörke Rare 2
- Cladonia cariosa* (Ach.) Spreng. Rare 1
- Cladonia cenotea* (Ach.) Schaer. Rare 24
- Cladonia chlorophaea* (Flörke ex Somm.) Spreng. 2, 5, 7, 8
- Cladonia ciniocraea* (Flörke) Spreng. Common, 6 loc.
- Cladonia crispata* (Ach.) Flot. 1, 11, 19, 21, 27
- Cladonia cristatella* Tuck. Common, 18 loc.
- Cladonia cryptochlorophaea* Asah. Common, 6 loc.
- Cladonia deformis* (L.) Hoffm. Rare 1
- Cladonia digitata* (L.) Hoffm. Rare 24
- Cladonia fimbriata* (L.) Fr. Common, 7 loc.
- Cladonia gracilis* (L.) Willd. 1, 7, 11, 21, 26
- Cladonia grayi* G. K. Merr. ex Sandst. 3, 4, 5
- Cladonia macilentia* Hoffm. Rare 4
- Cladonia multififormis* G. K. Merr. Rare 1
- Cladonia parasitica* (Hoffm.) Hoffm. Rare 4
- Cladonia phyllophora* Ehrh. ex Hoffm. Common, 14 loc.
- Cladonia pleurota* (Flörke) Schaer. 11, 19, 20, 27
- Cladonia polycarpoides* Nyl. 7, 20
- Cladonia pyxidata* (L.) Hoffm. Common, 15 loc.
- Cladonia ramulosa* (With.) Laundon 6, 24
- Cladonia rei* Schaer. Common, 9 loc.
- Cladonia squamosa* (Scop.) Hoffm. 4, 24
- Cladonia symphyocarpa* (Ach.) Fr. 7, 12, 18, 23
- Cladonia turgida* Ehrh. ex Hoffm. 11, 24
- Cladonia uccialis* (L.) Web. ex Wigg. Common, 10 loc.
- Cladonia verticillata* (Hoffm.) Schaer. Common, 12 loc.
- Collema limosum* (Ach.) Ach. Rare 7
- Collema tenax* (Sw.) Ach. Rare 23
- Cyphelium tigillare* (Ach.) Ach. 13, 16, 18
- Evernia mesomorpha* Nyl. Common, 15 loc.
- Graphis scripta* (L.) Ach. (Armentano et al., 1985) Common, 10 loc.
- Gyalecta truncigena* (Ach.) Hepp Rare 17
- Haematomma pustulatum* Brodo & W. Culb. Rare 8
- Heterodermia obscurata* (Nyl.) Trev. Rare 8.
This represents a considerable northern range extension from the distribution given in Hale (1979) but Harris (1978) reported it from southern Michigan.
- Hypocenomyce anthracophila* (Nyl.) James & G. Schneid. Rare 24
- Hypocenomyce friesii* (Ach. in Lilj.) James & G. Schneid. 6, 24
- Hypocenomyce scalaris* (Ach. ex Lilj.) Choisy 21, 23
- Hypogymnia physodes* (L.) Nyl. Common, 13 loc.
- Imshaugia aleurites* (Ach.) S. F. Meyer Rare 1
- Imshaugia placorodia* (Ach.) S. F. Meyer, 2, 4, 23
- Julella fallaciosa* (Stizenb. ex Arn.) R. Harris 5, 6, 20, 24
- Lecanora allophana* Nyl. 2, 9, 14, 17
- Lecanora caesiorubella* Ach. subsp. *caesiorubella* 5, 14, 24
- Lecanora hybocarpa* (Tuck.) Brodo Common, 7 loc.
- Lecanora meridionalis* Magn. 4, 23
- Lecanora pallida* (Schreb.) Rabenh. var. *pallida* 2, 20, 22
- Lecanora pallida* var. *rubescens* Imsh. & Brodo 3, 4, 6, 21, 24
- Lecanora polytropa* (Hoffm.) Rabenh. Rare 18
- Lecanora pulcaris* (Pers.) Ach. 6, 21
- Lecanora saligna* (Schrad.) Zahlbr. Rare 20
- Lecanora sambuci* (Pers.) Nyl. 9, 25
- Lecanora strobilina* (Spreng.) Kieff. Common, 8 loc.
- Lecanora symmicta* (Ach.) Ach. Common, 7 loc.
- Lecanora thysanophora* Harris ined. Common, 8 loc.
- Lecidea erratica* Körb. Rare 7
- Lecidella euphorea* (Flörke) Hert. 13, 16, 25
- Lepraria finkii* (B. de. Lesd. in Hue) R. Harris 1, 3, 6
- Leptorhaphis epidermidis* (Ach.) Th. Fr. 3, 10
- Lobaria pulmonaria* (L.) Hoffm. Rare 8
- Micarea melaena* (Nyl.) Hedl. Rare 6
- Micarea peliocarpa* (Anzi) Coppins & R. Sant. 3, 12
- Mycocalicium subtile* (Pers.) Szat. Rare 12
- Ochrolechia arborea* (Kreyer) Almb. Common, 10 loc.
- Opegrapha varia* Pers. Rare 17
- Pachyospora verrucosa* (Ach.) Mass. 10, 17
- Pachyphiale fagicola* (Hepp ex Arn.) Zw. Rare 10

- Parmelia aurulenta* Tuck. 8, 10, 26
Parmelia boilliana Müll. Arg. (Armentano et al. 1985) Common, 11 loc.
Parmelia caperata (L.) Ach. Common, 17 loc.
Parmelia crinita Ach. (Armentano et al. 1985) 8, 22
Parmelia cumberlandia (Gyeln.) Hale Rare 18
Parmelia exasperatula Nyl. Rare 20
Parmelia flaventior Stirt. (Armentano et al. 1985) Common, 20 loc.
Parmelia hypoleucites Nyl. 2, 19, 27
Parmelia olivacea (L.) Ach. Rare 9
Parmelia rudecta Ach. (Armentano et al. 1985) Common, 15 loc.
Parmelia septentrionalis (Lynge) Ahti Rare 15
Parmelia soledica Nyl. 8, 13
Parmelia squarrosa Hale 10, 13
Parmelia subargentifera Nyl. Common, 6 loc.
Parmelia subaurifera Nyl. (Armentano et al. 1985) Common, 20 loc.
Parmelia subrudefecta Nyl. 21, 23, 24
Parmelia subtinctoria Zahlbr. Rare 5. This is a northern range extension for this species that is found mainly in the southeastern United States (Hale 1979).
Parmelia sulcata Tayl. (Armentano et al. 1985) Common, 23 loc.
Peltigera canina (L.) Willd. 4, 21, 24
Peltigera didactyla (With.) Laundon 12, 13, 15
Peltigera elisabethae Gyeln. 2, 5
Peltigera evansiana Gyeln. 5, 8
Peltigera lepidophora (Nyl. ex Vain.) Bitter 18, 20
Peltigera polydactyla (Neck.) Hoffm. Rare 2
Peltigera praetextata (Flörke ex Somm.) Zopf Rare 2
Peltigera rufescens (Weis.) Humb. Common, 6 loc.
Pertusaria amara (Ach.) Nyl. 2, 5, 24
Pertusaria macounii (Lamb) Dibb. 2, 5, 26
Pertusaria velata (Turn.) Nyl. Rare 2
Phaeocalcium curtissi (Tuck.) Tibell Rare 19
[Phaeophyscia adiascola (Essl.) Essl. (Armentano et al. 1985)]
Phaeophyscia cernohorskyi (Nadv.) Essl. Rare 9
Phaeophyscia chloantha (Ach.) Moberg 2, 13, 17
Phaeophyscia ciliata (Hoffm.) Moberg (Armentano et al. 1985) 2, 9, 25
Phaeophyscia hirsuta (Meresch.) Moberg Rare 17
[Phaeophyscia hirtella Essl. (Armentano et al. 1985)]
Phaeophyscia imbricata (Vain.) Essl. 17, 26
Phaeophyscia orbicularis (Neck.) Moberg Rare 17
Phaeophyscia pusilloides (Zahlbr.) Essl. Rare 2
Phaeophyscia rubropulchra (Degel.) Moberg (Armentano et al. 1985) Common, 13 loc.
Physcia adscendens (Th. Fr.) Oliv. (Armentano et al. 1985) Common, 12 loc.
Physcia aipolia (Ehrh. ex Humb.) Füllr. (Armentano et al. 1985) Common, 6 loc.
Physcia americana G. K. Merr. in Evans & Meyrow. 2, 10, 16, 17, 26
Physcia millegrana Degel. (Armentano et al. 1985) Common, 14 loc.
Physcia stellaris (L.) Nyl. (Armentano et al. 1985) Common, 13 loc.
Physconia detera (Nyl.) Poelt (Armentano et al. 1985) I found some specimens with a weak K+ yellow reaction on the soredia but lacking any yellow color of medulla and without yellow soredia as is supposed to be characteristic of *P. enteroxantha*. I have collected some typical *P. enteroxantha* in the western U.S. but it probably does not occur in the Great Lakes area. Common, 13 loc.
[Physconia enteroxantha (Nyl.) Poelt (Armentano et al. 1985) But see under *P. detera*]
Placynthiella icmalea (Ach.) Coppins & James Common, 6 loc.
Placynthiella oligotropha (Laund.) Coppins & James 1, 3, 27
Platismatia tuckermanii (Oakes) W. & C. Culb. 2, 4, 23
Porpidia macrocarpa (DC. in Lam. & DC.) Hert. & Schwab (including *P. crustulata*) 7, 18. A forthcoming revision of this genus will recognize several new species in this group and some of these collections may actually be other species.
Pyrenula laevigata (Pers.) Arn. Rare 8
Pyrenula pseudobufonia (Rehm) R. Harris 5, 10, 24
Ramalina americana Hale (Armentano et al. 1985) Common, 7 loc.
Ramalina dilacerata (Hoffm.) Hoffm. Rare 22
Rinodina exigua (Ach.) Gray Rare 5
Rinodina milliaria Tuck. Rare 13
Rinodina populicola Magn. Rare 2
Sarcogyne regularis Körb. 7, 12
Scoliciosporum chlorococcum (Grave ex Stenh.) Vezda Common, 11 loc.

- Sphinctrina anglica* Nyl. Rare 23
Stereocaulon saxatile Magn. Common, 6 loc.
Thrombium epigaeum (Pers.) Wallr. Rare 16
Trapelia involuta (Tayl.) Hert. 1, 13
Trapeliopsis flexuosa (Fr.) Coppins & James 1, 7, 13
Trapeliopsis granulosa (Ehrh.) Lumbsch. Common, 9 loc.
Usnea hirta (L.) Weber ex Wigg. Common, 8 loc.
Usnea subfloridana Stirt. 21, 22, 24
Verrucaria glaucovirens Grumm. Rare 7
Verrucaria muralis Ach. (including *V. rupestris*) 1, 7, 12, 15, 23
Xanthoria fallax (Hepp in Arn.) Arn. (Armentano et al. 1985) Common, 8 loc.
Xanthoria polycarpa (Hoffm.) Rieber (Armentano et al. 1985) 2, 5, 9, 25

DISCUSSION OF FLORA

The list includes 180 taxa found in this study. The lichen flora is relatively good for a dry or shady area with many hardwood forests. The most common species are *Cladina mitis*, *Cladonia cristatella*, *Cladonia phyllophora*, *Evernia mesomorpha*, *Parmelia flaventior*, and *Parmelia sulcata*. Of the 23 species reported by Armentano et al. (1985), four were not found in 1987. These four species are rare or require rare substrates and were missed by me, or are misidentifications.

Many species do not have distributional ranges this far south except in very moist habitats, such as in the bogs, where most of the rare northern species were found. The relatively undisturbed hardwood forests have few lichens, partly due to the dense shade. Some additional lichens might occur in the tree tops but usually they can also be found along the forest edge, along roadsides or in abandoned farmlands. Although the forests were mostly logged at one time in the past, the present trees are mature and it is unlikely that the logging influence still persists on the lichen flora. The trees of open abandoned farmyards, gravel pits and abandoned orchards produced many lichens.

The woodlands on stabilized dunes near shore with open jack pines were especially good for lichens. Many species were collected from the trees and on the ground in these habitats. Even the balsam poplar trees behind Sleeping Bear Dune were almost covered with lichens. There are few rocks in the park but several lichens were found on rocks and concrete around gravel pits and abandoned farms.

The locality with the highest number of rare species is 3 miles south of Empire at Esch Road (locality # 2) closely followed by localities northwest of Little Platte Lake (locality # 4) and at the northern tip of Pyramid Point (locality # 17). Localities with *Thuja* as at the Esch Road location are always rich in species. The other two localities have open jack pines with old logs and stumps providing good habitats for lichens.

This list of 180 taxa presents the first complete listing of lichens for the park and includes one new record for North America (*Arthonia fuliginosa*) and a significant northern extension of the range of *Heterodermia obscurata*. The study by Armentano et al. (1985) only included a few kinds of substrates at a limited number of localities.

The study was made possible by funds from the National Park Service. The park personnel have been very helpful during the field work which has contributed significantly to the success of the project. Dr. James Bennett provided suggestions on the field work and the manuscript. The assistance of all of these is gratefully acknowledged.

COLLECTION LOCALITIES

The following is a list of collection localities for this study. The number at the beginning of each locality description is cited in the species list.

LEELANAU COUNTY

1. 2 miles south of Empire. Around old gravel pit on west side of highway 22 with some maple and green ash around edges. Sec. 31, T28N, R14W. 29 June 1987.

BENZIE COUNTY

2. At lakeshore 3 miles south of Empire at end of Esch Road. Behind foredune in mixed hardwood forest with hemlock, *Thuja* and pines. Sec. 1, T27N, R15W. 29 June 1987.
3. NE of Bass Lake at Trails End. Along shore and back from lake in mixed open forest with oaks, aspens and openings. Sec. 13, T27N, R15W. 29 June 1987.
4. NW of Little Platte Lake at end of Peterson Road. On dunes back from shore with jack pines, white pines and juniper. Sec. 22, T27N, R15W. 30 June 1987.
5. Platte River Point. Behind first dune and along shore in hardwoods with some pines east of road. Sec. 20, T27N, R15W. 30 June 1987.
6. 1 mile south of Platte River Point at end of Cooper Road. In hardwood forests between low wet areas with alder and *Thuja*. Sec. 29, T27N, R15W. 30 June 1987.
7. At west end of Long Lake north of Crystal Lake. In open field north of road with some maples and sumac. Sec. 36, T27N, R16W. 30 June 1987.

LEELANAU COUNTY

8. At north end of North Bar Lake (2.5 miles N of Empire). Along edge and in bog with *Thuja*, black ash, some yellow birch and brush. Sec. 12, T28N, R15W. 1 July 1987.
9. Just east of Sleeping Bear Dune on dunes with juniper and scattered big tooth aspen. Sec. 31, T29N, R14W. 1 July 1987.
10. 1.5 miles west of Burdickville on south shore of Glen Lake. On ridgetop in sugar maple and beech forest with some ash and white birch. Sec. 11, T28N, R14W. 1 July 1987.
11. 1.5 miles south of Glen Lake narrows. On northwest facing open slope with scattered young sugar maple, juniper and brush. Sec. 15, T28N, R14W. 1 July 1987.
12. Sleeping Bear Point 1 mile northwest of Glen Haven. Near shore of Lake Michigan with jack pines on ridges and swamps in low areas. Sec. 17, T29N, R14W. 2 July 1987.
13. 1 mile south of Glen Haven at former farmsite. In open fields and around open yard trees. Sec. 29, T29N, R14W. 2 July 1987.
14. At south edge of Glen Arbor south of cemetery. In dense beech-sugar maple forest with a few pines. Sec. 27, T29N, R14W. 2 July 1987.
15. Just west of Tucker Lake 1 mile east of Glen Arbor. In abandoned field with some sumac. Sec. 24, T29N, R14W. 2 July 1987.
16. 3.5 miles northeast of Glen Arbor. At old gravel pit and around roadside trees. Sec. 12, T29N, R14W. 3 July 1987.
17. At northern tip of Pyramid Point. On sand cliffs near lake in hardwood forest with beech, maple and some *Thuja*. Sec. 31, T30N, R13W. 3 July 1987.

18. 1 mile west of Shell Lake on Pyramid Point. In old field with some pines, sugar maples and sumac. Sec. 6, T29N, R13W. 3 July 1987.
19. 4 miles northeast of Glen Arbor at boundary of park west of Bass Lake. In apple orchard and abandoned fields. Sec. 7, T29N, R13W. 3 July 1987.
20. South Manitou Island. Near center of island in old orchard and open fields with scattered maples, sumac and juniper. Sec. 4, T30N, R15W. 4 July 1987.
21. South Manitou Island. Northwest of ranger station at lighthouse in jack pines back from beach with some *Thuja* and balsam fir. Sec. 3, T30N, R15W. 5 July 1987.
22. South Manitou Island. 1 mile southwest of ranger station and lighthouse near shore in maple-aspen forest with some *Thuja*. Sec. 10, T30N, R15W. 5 July 1987.
23. Good Harbor Bay southeast of Shalda Creek. Near shore in open jack pines and juniper between road and lake. Sec. 4, T29N, R13W. 7 July 1987.
24. Good Harbor Bay north of Little Traverse Lake. Back from shore in woods with oaks, pines and openings and some quaking aspens. Sec. 3 & 10, T29N, R13W. 7 July 1987.
25. Good Harbor Bay at northeast end of park east of Good harbor Creek. Near shore in grove of balsam poplar on sand dunes. Sec. 6, T29N, R12W. 7 July 1987.
26. West of Empire Bluffs just south of Empire. In openings and along ridge with ash, maple and oak. Sec. 25, T28N, R15W. 8 July 1987.
27. 2 miles northeast of Empire just north of Voice Road. In old field on hillside with sumac. Sec. 18, T28N, R14W. 8 July 1987.

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**SIMPLE-LEAVED ASHES (FRAXINUS: OLEACEAE)
IN MICHIGAN**

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We report striking forms of native Michigan ashes that involve radical departures from the typical mature leaf structure, in this case from pinately compound to simple. The concept of form as usually adopted in modern plant taxonomy involves divergence from the norm in only one or a few characters, and the appearance of the divergence only sporadically, usually not a population but a single individual. The same form may reappear in different populations of the same species. Thus, while varieties and subspecies tend to occur over large areas in more or less continuous populations, forms may turn up here and there, mixed with normal members of the species. Some forms are caused by environmental influences (an example in Michigan is *Onoclea sensibilis* f. *obtusilobata*, Beitel et al. 1981). Others are genetically controlled. The latter include changes in plant habit such as dwarfing or pendent shoots, and in leaf form such as will be described here. Divergence in floral characters are well known, for example, the familiar white forms of certain orchids, *Pogonia*, *Arethusa*, *Cypripedium* (Case 1987), or bisexual forms of usually unisexual species, the last illustrated in Michigan by species of *Acer* (Wagner 1975a) and *Salix* (Wagner 1968). Sometimes forms are given names and sometimes not. Generally forms induced by outside factors such as stress or disease are ignored nomenclaturally because they have no special evolutionary potential. Unusually conspicuous or peculiar genetically controlled ones are often given names because of their striking character. Whether named or not, genetic forms have definite biological interest. Sometimes they seem to show ancestral traits and are referred to as "throwbacks". In others, the changes associated with maturation do not take place and so we have persistent juveniles. A single gene mutation can sometimes produce unexpectedly profound changes (Hilu 1983). For mankind, forms often lead to important useful plants such as the cabbage "varieties" — actually forms — such as kale, Brus-

sels sprouts, cauliflower, and many others. Mutations of the snapdragon have been used for genetic and developmental studies. Some forms are conserved because of their beauty or unusual appearance, as is illustrated by bronze maple or weeping beech. In this paper we will describe the ordinary leaf variation of ashes from early foliage of seedlings to mature foliage of older saplings. With this as background we will then describe two types of simple-leaved ashes from Michigan and their potential significance.

SIMPLE JUVENILE LEAVES: THE HETEROBLASTIC LEAF SERIES

Higher plants have an open system of growth, as opposed to animals with a closed system. Plants are thus capable theoretically of unlimited growth and the formation of more and more organs by adding new parts and branching. This process begins in the seedling, and in woody plants through progressive sapling stages in the mature, sexually reproductive shrub or tree. This "modular" growth pattern produces in the shoot system successive nodes and internodes, the first where the leaves and lateral buds arise, the second the naked elongated stem increments between the nodes. Going from young seedling to older and older saplings, the foliage leaves produced at the nodes change successively from early juvenile leaves to adult leaves (Figs. 1-3). A tree thus produces different kinds of foliage leaves at different stages of its maturation so that there is a graded series known as an heteroblastic series, showing differences in size and shape. The ashes, like most other compound-leaved plants, start out with simple leaves in the early seedling (Fig. 1a), but the successive leaves become ternate (with three leaflets, an opposite pair plus the terminal one—Fig. 1b, 2) and then pinnate (with varying numbers of pairs of leaflets plus the terminal leaflet, in the ashes under consideration here ranging from 5 leaflets total to 9, and averaging between 7 and 9—Fig. 3). Since all ashes go through the same stages, for purposes of this paper we use the heteroblastic series in the red ash, *Fraxinus pennsylvanica*, to illustrate the characteristic sequence.

The following description is based on seedlings with stems ca. 1 mm thick, between 10 and 15 cm tall, and with 5-12 nodes. The young plants were abundant below and near full-sized parent trees in old second-growth woods in Washtenaw Co., MI (Lyndon Twp. Sec. 29). A collection was made to show the heteroblastic series, starting with small simple leaves to large compound leaves, the latter from older saplings over 1 m tall (*Wagner* 87533, MICH).

The smallest leaves in this series (except for casual midjet leaves from near the apical bud, Fig. 1a) are around 4 cm long. The blade is lanceolate, 3×1.5 cm, entire or nearly so. The rare large simple leaves have the same blade outline. The petiole is usually 2 cm long, and the blade 14.5×5.5 cm. In terms of over-all leaf length, the transition from simple to ternate occurs between 5 and 15 cm, but most of the leaves less than 10 cm long are simple and most of those over 10 cm are ternate or more divided (Figs. 1b-3).



Fig. 1. Young saplings of *Fraxinus pennsylvanica*. a. Simple-leaved early stages. b. Lobed and ternate-leaved forms. Note those leaves that are pinnate on one side and simple on the other. Scale = 5 cm.

Leaves from the same node are closely matched in outline and size, but there are exceptions (Fig. 1a,b). Interesting morphologically are those leaves which have leaflets, only on one side of the leaf (Fig. 1b). Most leaves over 20 cm long in the seedling-sapling population studied have two or more pinna pairs. By the time the stem is over 2–3 mm in diameter the leaves have mainly 2–3 pairs of leaflets, and at 3–5 mm the leaves begin having four pairs (Figs. 2, 3). The mature leaves on stems over 5 mm in thickness may have up to four pairs. Counting the terminal pinna, then, we say that the mature leaves have 7–9 leaflets. The terminal pinna, then, we say that the mature leaves have 7–9 leaflets. The terminal pinna in mature leaves tends to be oblanceolate, a condition not seen in the lateral leaflets. The heteroblastic changes from simple seedling leaves to mature maximum-sized leaves pass through these steps (counting the terminal pinna): 1-3-5-7-9 (Fig. 3). Any one of these steps may be eliminated on vigorous plants, or there

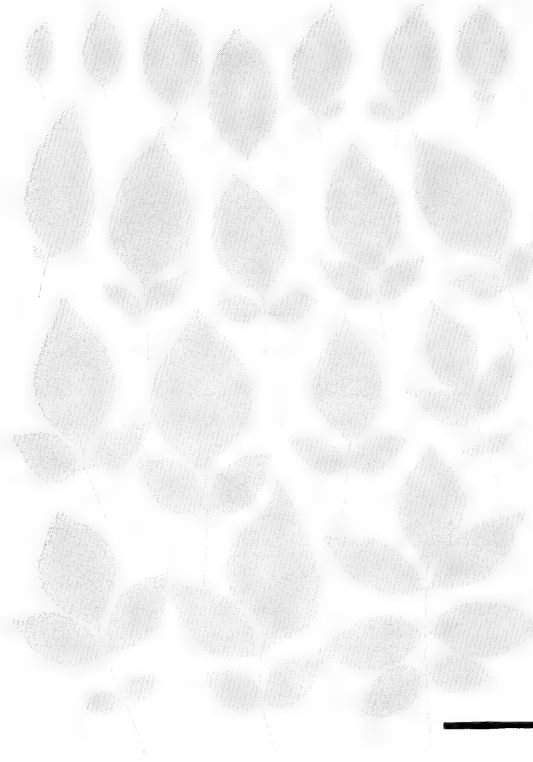


Fig. 2. Transitions from early to late sapling forms in *F. pennsylvanica*. Youngest stages top left, oldest bottom right; from simple to 5 leaflets. Scale = 5 cm.

may be intermediate forms (e.g., leaflets on only one side of the leaf — Figs. 1b, 2). One simple leaf blade represents the earliest phase in seedlings; 3–5 leaflets including the terminal, young sapling phases; and 7–9, older saplings and fully mature trees. It should be noted that the juvenile simple leaves are never large, only rarely reaching more than 12 cm in length. This is in marked contrast to the types of simple leaves of the ash to be described below.

“PEACH-LEAVED” SHOOTS: EFFECTS OF ASH YELLOWS DISEASE

A sapling of this simple-leaved form was first observed in Michigan in 1980 by W. Keith Stewart, along the woodland trails at the Emma Bingham Outdoor Education Center, St. Louis, Gratiot Co., Michigan. (It was reported in the paper “Atypical Leaf Form in *Fraxinus*” by Stewart and



Fig. 3. Late young sapling leaves to mature leaf types, left to right, 3 to 9 leaflets, in *F. pennsylvanica*. Scale = 5 cm.

Kapp at the 1981 Michigan Academy of Sciences Meeting.) Further individuals were discovered at this locality by Kapp in 1987. At the same time Wagner found a number of specimens in Washtenaw Co. in a woodlot near Dexter owned by Mr. and Mrs. John Cares.

This form is different from both the seedling form described above and genetically controlled adult form described below. The simple leaves are borne mostly on narrow, delicate, straight branchlets 0.4–1.5 mm thick, often grouped in the form of an open witches broom (Figs. 4, 5), with as many as ten branches arising close to each other. With practically no exceptions, normally pinnate leaves are found, if not with the simple leaves, at least elsewhere on the same plant. Intermediates between the normal and the simple leaves are common, including ones with basal lobes and ones with basal pinnae (Fig. 5). The leaves themselves tend to be thin-textured and generally narrowly lanceolate to linear lanceolate, somewhat like peach leaves in outline (Fig. 5). The margins are generally entire but may be somewhat sinuate or rarely coarsely but shallowly dentate. The shoots with simple leaves and narrow branches have a decidedly abnormal or diseased appearance. These shoots stand out as peculiar among the usually much more common normal pinnate-leaved and thick-twigged shoots. One sapling found by Kapp had simple leaves dominating at the top and pinnate leaves at the bottom. A large majority of the abnormal shoots arise from the node or nodes just below a point at which the parental shoot has been broken off or atrophied, leaving a dead tip (Fig. 4, base of shoot). It is interesting to note that in the Cares' woods as in the Brigham Center woods,



Fig. 4. "Witches broom" produced by Ash Yellows. Note the numerous, slender branches and narrow simple leaves. *F. americana* sapling, Washtenaw Co., MI, *Wagner 87535* (MICH). Scale = 5 cm.

the saplings with abnormal branches grow along trails. The peculiar condition may be stimulated by the breaking of shoots. The Cares inform us that snowmobiles are very active along the trails during winter. It may be caused instead by tip die-backs.

The peculiar simple "peach leaves" are caused by the effects of a pathogen. We consulted Wayne A. Sinclair, plant pathologist at Cornell University, who kindly examined specimens sent him from St. Louis, and confirmed that they contained the organism that causes the disease known as "ash yellows", which is described in detail in various publications (see Sinclair et al. 1987). White ash is the species most attacked by the disease, but red (*F. pennsylvanica*), black (*F. nigra*), and blue ashes (*F. quadrangulata*) may also be susceptible. It is caused by mycoplasma-like organisms (MLAs) and can cause decline and premature death of the infected trees. The presence of witches brooms is one of the surest indicators of an infection. We are informed by Professor Sinclair that the disease has increased greatly in the Midwest over the past ten or fifteen years.

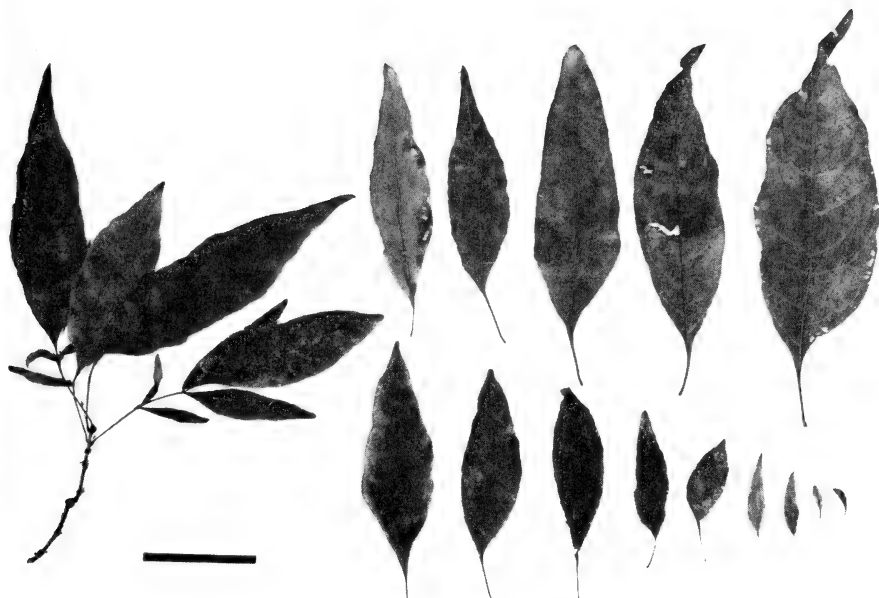


Fig. 5. Leaf forms from Ash Yellows witches brooms. *F. americana* saplings, Washtenaw Co., MI, Wagner 87535 (MICH). Scale = 5 cm.

WHOLE SIMPLE-LEAVED TREES: GENETICALLY CONTROLLED FORM

Although the presence of simple leaves characterizes all young ash seedlings and the witches brooms of ash yellows disease, their presence on older saplings and mature trees is extremely rare. Normally the older individuals have 5–9 leaflets. We here describe a population of white ashes, *Fraxinus americana*, from Kalkaska Co., Michigan, in Blue Lake Township not far from Big Twin Lake. The original simple-leaved tree (Fig. 6) was discovered by Robert Barr, Grounds Manager of the Au Sable Institute. Alan Gebben of Calvin College was the first to recognize it as a form of *F. americana*. We find no mention of such a form of this species in any of numerous floras and dendrology texts that we consulted. However, there is reason not to suppose that someday more populations of simple-leaved white ash will be discovered in Michigan or elsewhere (see below, under polytopic origins), or of other ash species, especially the equally common red ash, *F. pennsylvanica*, the early stages of which were described above. Superficially white ash and red ash are similar, but Taylor (1972) compared them in considerable detail and found 27 differences of varying degrees of reliability for separating them. Some of the more useful differences are summarized by Barnes and Wagner (1981).



Fig. 6. Silhouette of full-sized, mature tree of *F. americana* f. *barrii*, showing denser foliage at top. Height 55 feet. Kalkaska Co., MI.

The locality in which the simple-leaved white ash grows is a mainly second-growth woods of perhaps 30–40 years in age. Beside numerous normal-leaved white ashes, especially numerous saplings, the most common woodland species include *Amelanchier arborea*, *Fagus americana*, *Ostrya virginiana*, *Populus tremuloides*, *Tilia americana*, and *Ulmus americana*. *Rubus idaeus* is a common shrub, especially along trails and roads in the vicinity. In addition there are such other woody plants as *Acer saccharum*, *Betula papyrifera*, *Cornus alternifolia*, *Pinus strobus*, *P. resinosa*, *Populus grandidentata*, *Prinus virginiana*, *Quercus alba*, *Q. rubra*, and *Rhus typhina*. This species list defines a rather rich successional flora leading to the mesic climax forest type that is usually referred to as the beech-sugar maple forest, a community that very commonly contains white ash.

The population of simple-leaved white ash is made up of one mature flowering tree plus numerous saplings. The mature individual has four nearly equal-sized trunks, the largest 16.7 m tall, 30.7 cm in diameter at breast height, and 41 years old as determined by coring. The type specimen was taken from this tree (Figs. 6, 7). This tree and an associated normal pinnate-leaved white ash of approximately equal size growing about 10 m away are both made up of old stump sprouts indicating that they were both either cut down or otherwise damaged at the ground level decades ago. Thus both trees are probably considerably older than 40 years. The simple-leaved tree is heavily and conspicuously infected with the ash-flower gall mite, *Aceria fraxinovorius*, which converts the male inflorescences after flowering into pendent masses of hard, irregular galls. The foliage is most dense in the upper part of the tree (Fig. 6, silhouette). In the paragraphs below we shall refer to the simple-leaved tree as male (as there are no fruits and the galls apparently form only from male flowers, Barnes and Wagner 1981). The compound-leaved tree is a female; there is no evidence of galls, and the fruiting panicles contain only fruits, many of which have fallen and litter the ground below. We use the terms male and female to refer to these plants in accordance with the proposals of Wagner (1957b); the more cumbersome terms staminate and pistillate may be used as well.

At least 150–200 simple-leaved saplings ranging in height from 0.3 to 4.5 m grow in close association with the more abundant normal compound-leaved saplings. Both types of saplings are most abundant near the female tree (Fig. 7b), but we were able to find scattered simple-leaved saplings up to at least 100 m away in the nearby woods and at the edges of clearings, indicating wind dispersal of the samaras from the female tree. We had to restrict our rough estimates of the numbers of simple-leaved saplings to those over 1 foot (0.3 m) tall, because smaller juveniles of pinnate forms have simple leaves, as described above. By the time the plants grow to 0.3 m, the differences between the compound and simple forms have become well established. If we could identify with certainty the smaller plants as belonging to the simple-leaved form it is possible that the actual numbers of its seedlings would be increased several-fold, as young white ash seedlings in general are extremely common. From our observations of the older individuals we estimate that the simple-leaved form comprises no more than 10 per cent of the sapling population and probably less.

The leaves of the simple form are borne in variable numbers along the twigs, depending on the number of nodes. On the leader branches (sapling apex and the tips of major lateral branches), there may be 4–10 nodes per twig (Fig. 7a). The small side branches run 2–5 nodes. The leaves are opposite, and the members of each pair of leaves tend to match one another in size and outline. However, the node next to the terminal bud may be irregular; only a single small leaf may be produced. The blade shape is ovate to lanceolate, 12–21 cm long, and 6–11 cm wide (Figs. 7a–9). The base of the blade forms a gradually narrowing wing along the upper part of the petiole. Rarely there is a lobe or narrow leaflet instead at the blade base. The widest part of the blade may be below, at, or above the middle. The tip of the blade

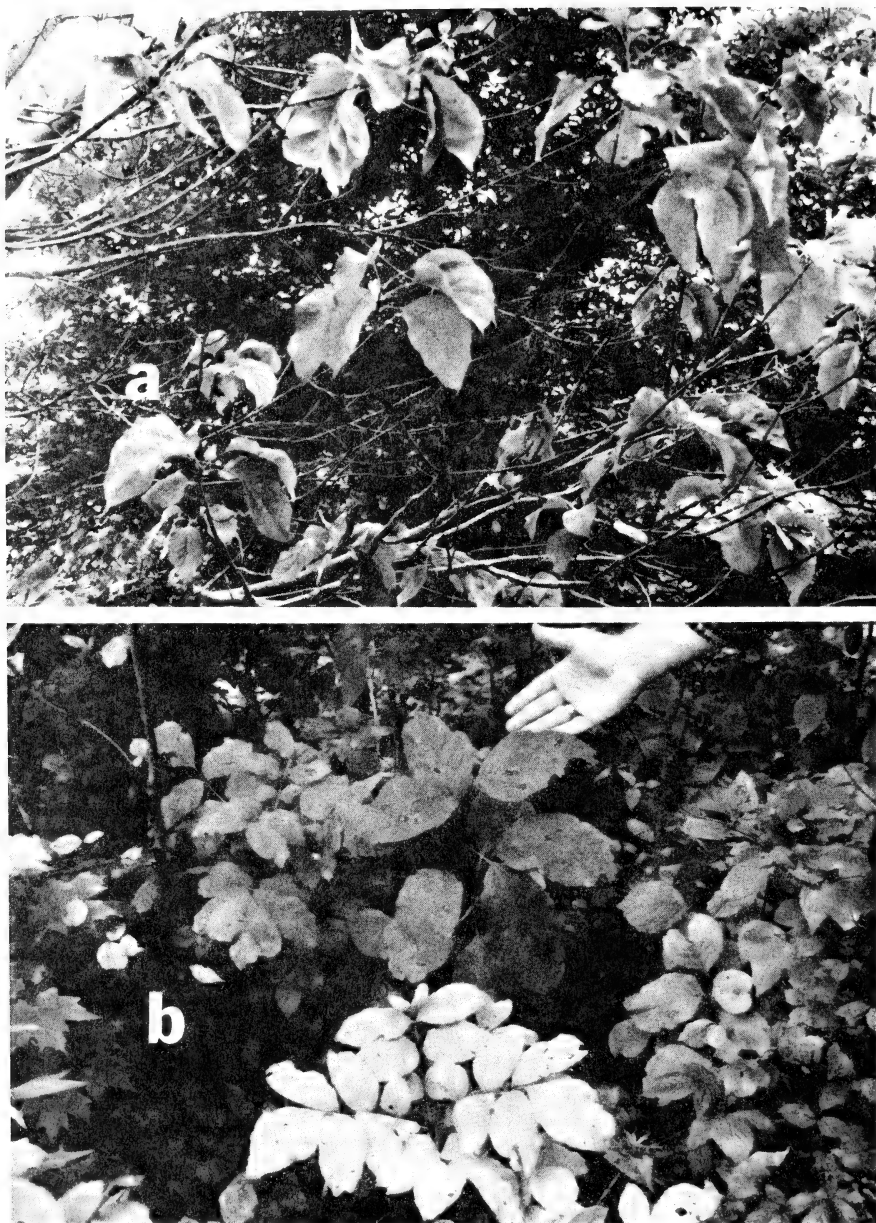


Fig. 7. *Fraxinus americana* f. *barrii*. a. Lateral shoots of tree, showing pendent leaves resembling large *Magnolia* leaves. b. Saplings. Comparison of simple-leaved f. *barrii* (with hand pointing to it) and normal pinnate-leaved individual (directly below it, paler color).

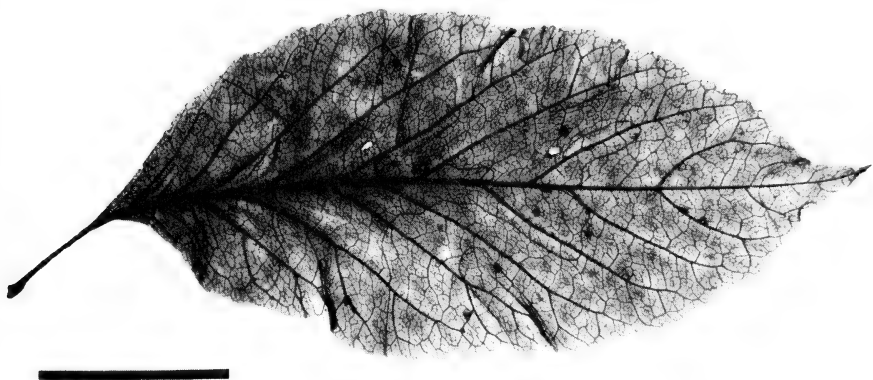


Fig. 8. Cleared simple leaf of *F. americana* f. *barrii*, showing the venation pattern, subopposite basally and apically, irregularly but mostly alternate medially. Scale = 5 cm.

is acuminate, with a projection ranging from 0.3 to 1.5 cm long. The margins are coarsely and irregularly but shallowly toothed to crenate, but rarely nearly entire in the lower third. The petioles, exclusive of the winged upper portion, average 2.6 cm long. The main lateral veins (Fig. 8) do not correspond to the midribs of leaflets of pinnate leaves; they are irregularly disposed, mostly alternate but sub-opposite toward the base and tip. The spacing of the veins does not necessarily match on the two sides; commonly two or more veins may originate closely on one side. The leaves tend to be more or less pendent, in contrast to the pinnate forms in which the leaves are spreading or horizontal (Fig. 7a).

We discovered a single sapling that was unusual in having leaf structure intermediate between the pinnate and the simple. This specimen, about 2 m tall, was characterized by its large number of ternate leaves mixed with simple leaves. The ternate leaves (Fig. 10) were borne mainly in the second and (or) third nodes from the apex. At other nodes simple leaves were paired with simple leaves, but in the intermediate nodes ternate leaves were paired with ternate leaves. These resemble somewhat the early intermediate leaves in the heteroblastic series (Fig. 2), but they are much larger and coarser. Out of a total of 116 leaves that we counted on this sapling, 46, nearly 40 per cent, were ternate. In all other simple-leaved plants, including the large tree the percentage of ternate leaves was very much less. It is interesting that not one of the divided leaves on the unusual plant had more than three leaflets.

Because of the very striking nature of the simple-leaved white ash described here, it is described and named as a taxonomic form, as follows:

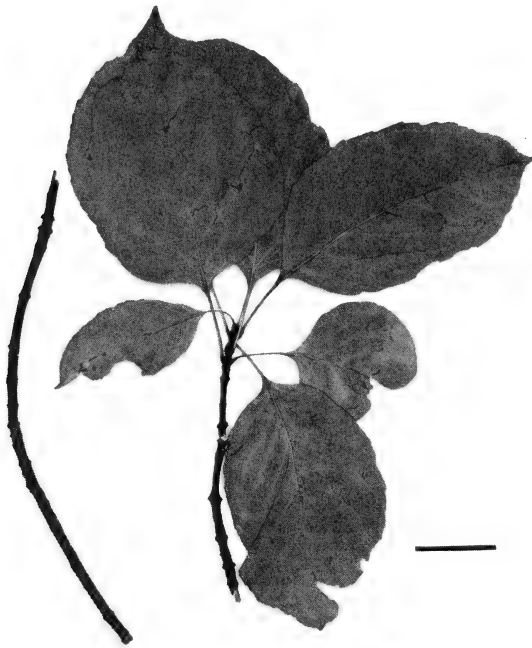


Fig. 9. Type specimen of *F. americana* f. *barrii*. Wagner et al. 87534 (MICH).

Fraxinus americana f. *barrii* W. H. Wagner, forma nova; different a *F. americana* f. *americana* foliis simplicibus (interdum ternatis), ovatis vel lanceolatis, acuminatis, grosse et irregulariter dentatis vel crenatis, petiolis 2–6 cm longis, laminis 12–21 cm longis, 6–11 cm latis.

Differing from the typical adult form of the species in having simple (sometimes ternate) ovate to lanceolate, acuminate, coarsely and irregularly dentate or crenate leaves, with petiole 2–6 cm long and blades 12–21 cm long and 6–11 cm wide.

Holotype: Michigan. Kalkaska Co., Blue Lake Twp. near Big Twin Lake. 28 August 1987. W. H. Wagner 87534 and G. Grieve, D. Johnson, D. Mahan, and S. Taylor (MICH, Fig. 9).

This plant is named for its discoverer, Robert Barr.

DISCUSSION

We have three types of simple-leaved ashes—those associated with juvenile stages of all species, those associated with “witches brooms”, and those associated with whole mature plants, genetically controlled. Of these the most interesting is the last. The simple-leaved *Fraxinus americana* f.

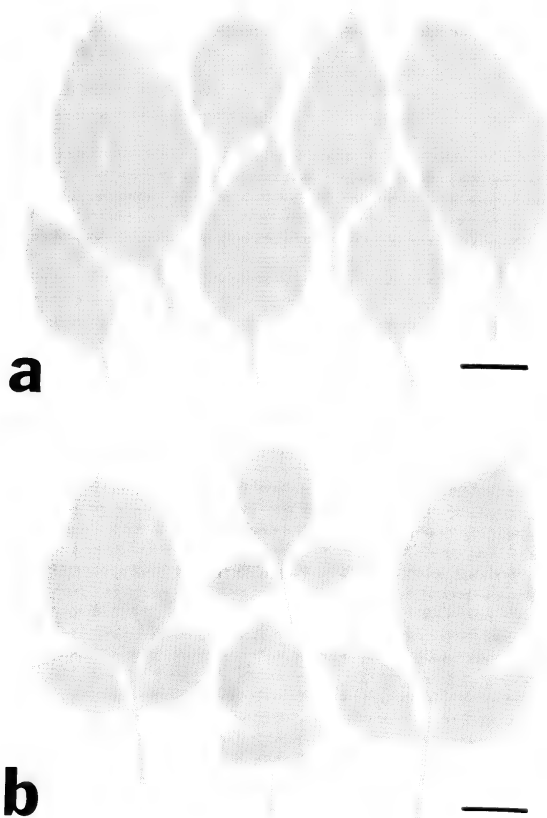


Fig. 10. Leaves of *F. americana* f. *barrii* showing variation. Leaves from saplings up to 4.5 m tall: a. Typical simple leaves. b. Ternate leaves that make up 40 per cent of the leaves of one sapling. (Compare Fig. 2, second and third rows from top.) Scale = 5 cm.

barrii is clearly representative of the taxonomic concept of form, even though at the one locality where it occurs together with the typical form of the species, the simple-leaved form is locally abundant. That it is genetic rather than environmental in origin is abundantly confirmed by the close association of the simple-leaved with the typical pinnate form, in mixtures of numerous plants growing side-by-side under the same conditions, a natural common garden experiment.

There are two famous simple-leaved adult ashes, one comprising forms of a naturally occurring species, the other a cultivated form. The first, the single leaf or dwarf ash, *Fraxinus anomala*, differs from the plant described here in that it is a shrub or small tree up to only 5 m tall, the simple leaves, ovate in outline and only 2–4 cm long. The same species also has pinnate forms. The single leaf ash has a wide range in southwestern North America

from northwestern New Mexico and western Colorado to southeastern California (Little 1953). The noted cultivated simple-leaved ash is one of the numerous garden forms of the European ash, *F. excelsior*. Named *F. excelsior* f. *diversifolia* (with a number of synonyms, Rehder 1940), it is grown widely in European and in British botanical gardens especially. Except for the simple leaves, it has the technical characters of European ash.

The significance of the natural simple-leaved mutant of white ash described here is not fully understood as yet. Biologically, the plant is interesting because in some senses it suggests a "throwback" or atavism. Presumably the ashes are derived originally from more primitive members of the olive family, the Oleaceae, which are primarily simple-leaved (but see below). Ashes are notable, or course, because they have become, like many temperate hardwoods, tall forest trees (rather than shrubs, as are so many Oleaceae), with unisexual flowers in many species (rather than bisexual), and wind-pollinated (rather than insect-pollinated). Their leaves have become compound with numerous leaflets, like forest trees in the Juglandaceae and Simourubaceae and their relatives.

Actually it is not true that all Oleaceae, except for *Fraxinus*, have simple leaves. Some of the garden forsythias often have 3-lobed or 3-foliolate leaves. The leaves of jasmine may be either simple or pinnate, and even an occasional lilac may have compound leaves; the "pinnate lilac", *Syringa pinnata*, is a shrub up to 3 m tall with compound leaves, the leaflets 7-11 (Rehder 1940). Another way of looking at the simple leaves of the white ash described here is that the juvenile condition has been retained. Juvenile ash leaves are simple, as shown above, but they are normally succeeded by adult-type compound leaves. However, in this case, the transformation has been eliminated. Successive leaves merely go on having a basically juvenile morphology, but getting larger and larger as the tree matures. The widespread phenomenon of neoteny is discussed by Davis & Heywood (1963, pp. 156-159), who state that in some cases "foliar differences are presumably controlled by genes which alter the timing at which particular leaf forms are produced, thus extending or telescoping the inherited sequences". One interesting feature of the upset in leaf morphology known in certain populations of the western *Fraxinus anomala*, *F. excelsior* f. *diversifolia*, and now *F. americana* f. *barrii* is that they are polytopic in origin (cf. Davis & Heywood, op. cit., pp. 448-451) in the sense that the same change has evidently taken place in at least three different places from three different stocks. The condition of mature simple ash leaves is thus polyphyletic. The possession of simple leaves does not necessarily indicate direct relationship, but instead the same potentiality for change from pinnate to simple.

An intriguing possibility is that the unusual leaf type of *F. americana* f. *barrii* is controlled by a single gene mutation with dramatic effects. There is strong current interest in the possibility that single gene changes may actually lead, directly or indirectly, to new lines of evolution abruptly, so that the traditional sequence of gradual change is by-passed in speciation. Various authors have discussed this possibility (e.g., Hilu 1983). The origin of

the widespread single leaf ash of southwestern North America may be traceable to a single gene mutation. Hilu (1983) discusses examples of changes in leaf structure in which the genetic basis has been studied in detail. In Barr's simple-leaved white ash described here, we have at present circumstantial evidence that the condition is controlled by a single gene. We believe that the maternal parent of the simple-leaved saplings is the pinnate-leaved tree growing only ca. 12 m away from the mature simple-leaved tree.

The circumstances of occurrence of the simple-leaved saplings strongly suggests that the female tree with normally pinnate leaves is the maternal parent, and that the male tree with simple leaves is the paternal parent. It is possible that the gene for simple leaves is a dominant gene, but generally new mutations tend to be recessive. At this point we can only conjecture what the genetic background of the saplings may be.

A possible genetic model is the following: Let P be the normal allele for adult pinnate leaf formation, and S the mutated allele for simple adult leaf. If the simple-leaved tree is the source of the pollen, then its formula is SS, and its pollen grain S. If the compound-leaved tree is the source of the egg and it is heterozygous, then its formula may be PS, and its eggs be either P or S. If P is dominant over S, then there will be only two morphotypes in the progeny. These are PS (heterozygous), and SS (homozygous). PS will be pinnate-leaved, because P is dominant. SS will show the double recessive condition, i.e., simple-leaved. This may explain why the progeny directly below the pinnate-leaved female tree includes simple-leaved saplings. The model described here would call for a ratio of one pinnate-leaved sapling to one simple-leaved. Actually the proportion of simple-leaved saplings appears to be considerably less than this. This might be explained by recessive factors that lower the survivability of SS seedlings, or by a pollen load present in the atmosphere at the time of pollination that comes from normal pinnate-leaved males with the dominant allele of P.

There are several possible outcomes from the investigation of Barr's white ash. One that immediately comes to mind is the potentiality that it may lead to the development of a valuable cultivar, like the simple-leaved European ash, *Fraxinus excelsior* f. *diversifolia*, that is now so widespread, especially in Old World in gardens and arboreta. The simple-leaved white ash is very striking, as the illustrations in this paper show. We can well imagine its use as a cultivated specimen-tree or as a shade tree in landscaping. In addition, the population of saplings at Big Twin Lake has the potential of providing research materials for botanists, foresters, and ecologists, as well as teaching materials for classes in organismic biology. The population, for example, may show the role that a single mutation can play in altering the structure of a population and influence the composition of a forest. Surely it will be worth while to pursue the genetics of this new form and to determine whether we are truly dealing with a single gene mutation of future evolutionary potential.

Finally, we must deal with the matter of conservation. Should we endeavor to preserve the population of simple-leaved white ash? It seems to us that there is no reason why we should not treat this remarkable form as

any endangered species. It is known from only a single wild population. Wanton destruction of habitat would no doubt eliminate this special kind of plant with its remarkable features. In spite of its status as a taxonomic form of a well-known species, the form is evidently capable of reproducing itself; it is exceedingly rare and local; it is natural phenomenon; and it has culture and scientific potentiality for the future. Precedent for proposing infraspecific taxa for classification as threatened or endangered already exists (Public Law 93-205, Endangered Species Act of 1973, Sec. 3, 11; Beaman et al. 1985). Not only do we wish to protect Barr's Ash from vandalism but we wish to give it and its forest a chance to continue uninterrupted as part of our state heritage. Consideration of the protection of this form opens up a number of questions pertaining to why we protect rare and endangered plants at all.

ACKNOWLEDGMENTS

We wish to thank the following individuals who contributed to this study: W. R. Anderson, B. V. Barnes, D. J. Bay, Mr. and Mrs. John Cares, Donald J. Johnson, David Mahon, and W. A. Sinclair. We are especially grateful to Robert Barr, who made the initial discovery of the simple-leaved white ash, and Alan I. Gebben, who was the first correctly to place it taxonomically.

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Editors' Note

One of us (JAW) has accepted a position with the U.S. Environmental Protection Agency's Environmental Research Laboratory in Corvallis, Oregon. By the time this issue reaches you, we will have moved to Corvallis. With a mixture of regret and anticipation we have tendered our resignation from the editorship of *The Michigan Botanist*—regret because we have enjoyed working on the journal, anticipation because of the new opportunities in Oregon. We will look forward to receiving the journal and continuing to learn about the plants of the Great Lakes region.

We are pleased to report that Drs. Richard Rabeler and Barbara Dyko have accepted the co-editorship of *The Michigan Botanist*. Both are associated with the University of Michigan Herbarium and are familiar with many aspects of the Michigan flora.

We thank everyone—authors, reviewers, editorial board members, and members of the Michigan Botanical Club—for helping us during our editorship. We wish the new editors all the best.

Jim and Nancy Weber

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On the cover: *Sea-rocket*, *Cakile edentula*, at *Fisherman's Island*
State Park, Charlevoix, Michigan
Photo by Manny Payne, 26 August 1987.

